

National Weather Service Flood Class



SKYWARN

May 28, 2015



Introduction



National Weather Service Mission

- ▶ The National Weather Service (NWS) provides weather, **hydrologic**, and climate **forecasts and warnings** for the United States, its territories, adjacent waters and ocean areas, **for the protection of life and property** and the enhancement of the national economy. NWS data and products form a national information database and infrastructure which can be used by other governmental agencies, the private sector, the public, and the global community.



Tonight's Topics

- ▶ Area of Responsibility
- ▶ Flood Facts & Flood Safety
- ▶ Water Monitoring / Basic Hydrology
- ▶ Flood Forecasting / Basic Meteorology
- ▶ Types of Flooding

Break

- ▶ NWS Products
- ▶ Observations
- ▶ Role of Spotters
- ▶ What to Report
- ▶ Case Studies
- ▶ Review



NWS Service Delivery Facilities



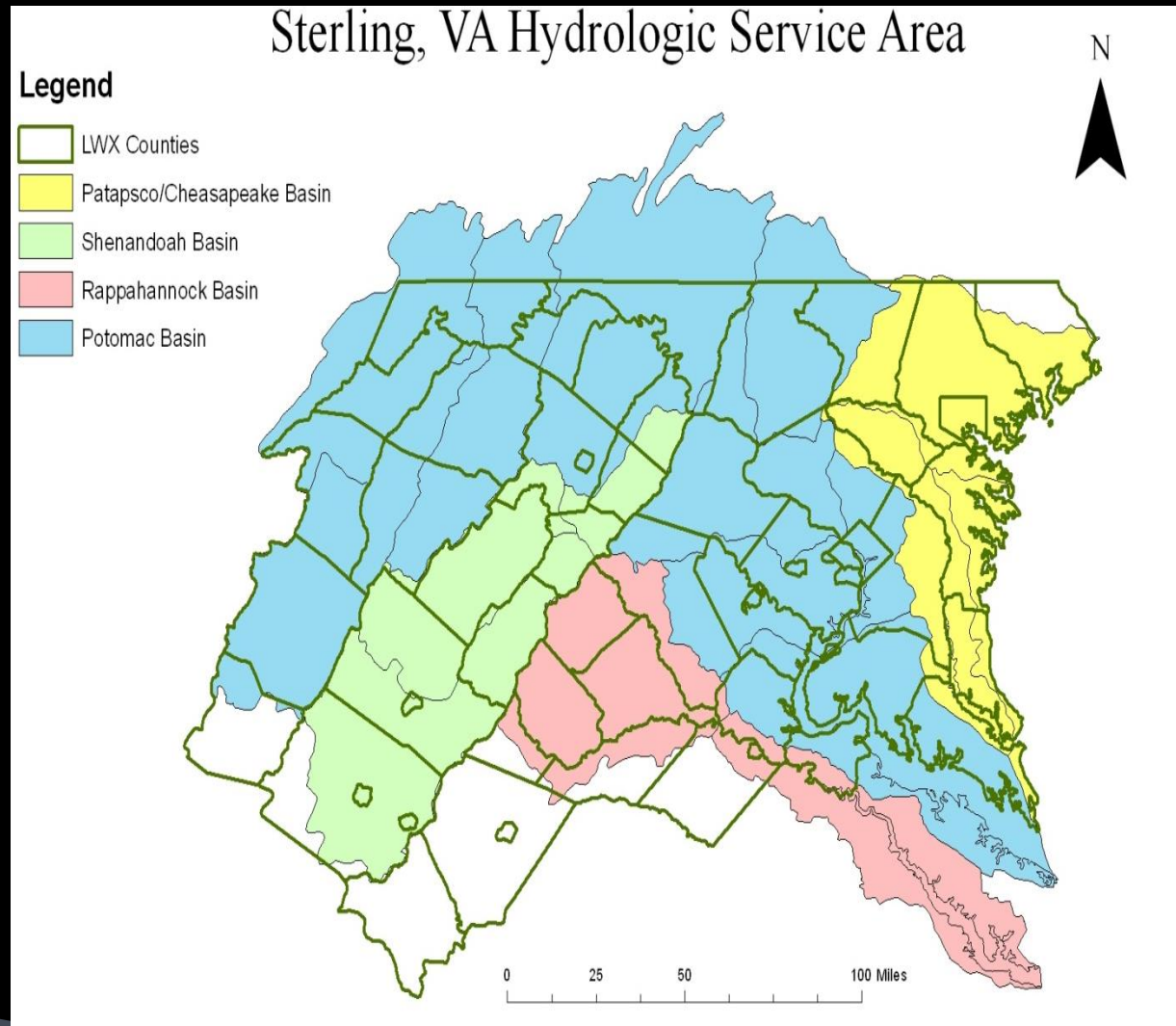
Areas of Responsibility

▶ County Warning Area (CWA) Flash Flood

- 43 Counties in 3 states
- District of Columbia
- 12 Independent Cities
- MD Chesapeake Bay

▶ Hydrologic Service Area (HSA) River Flood

- Potomac Basin
- Shenandoah Basin
- Rappahannock Basin
- West Chesapeake



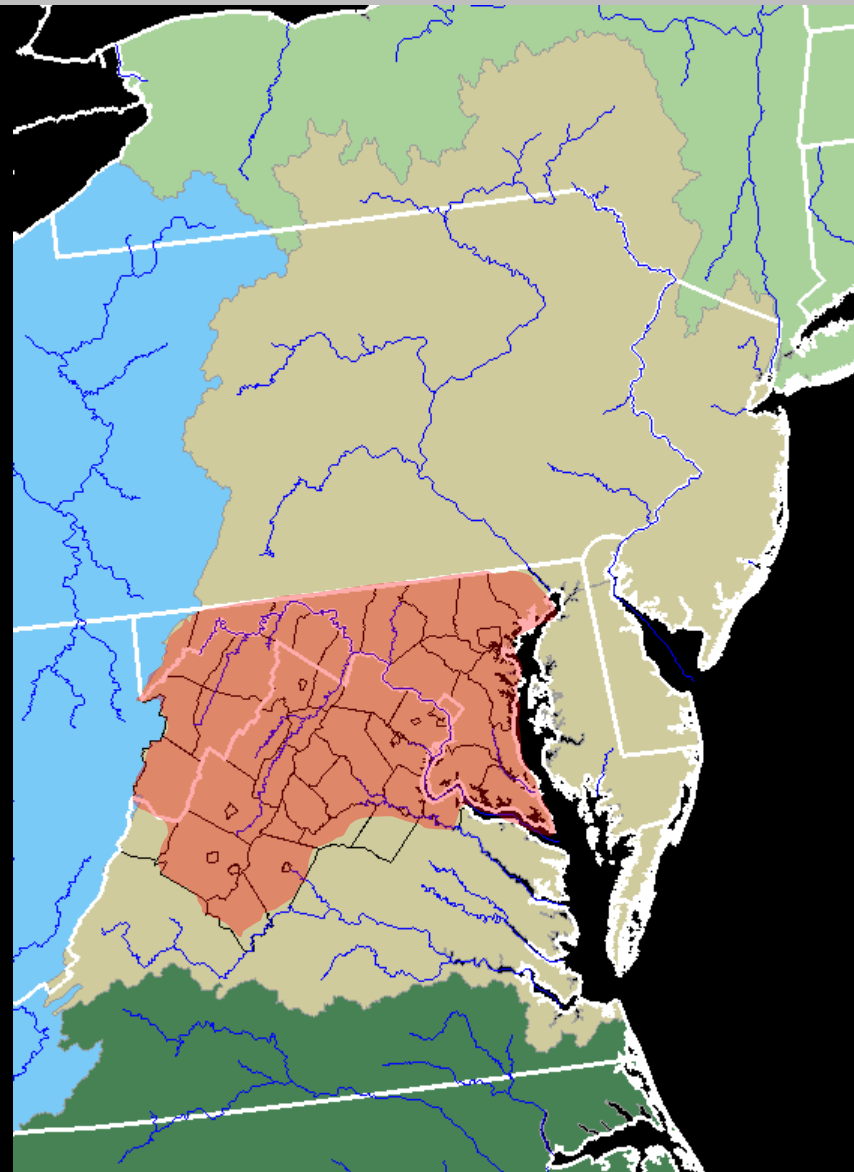
Hydrologic Staffing

► Weather Forecast Office

- 1 Service Hydrologist
 - *Not all offices even have this!*

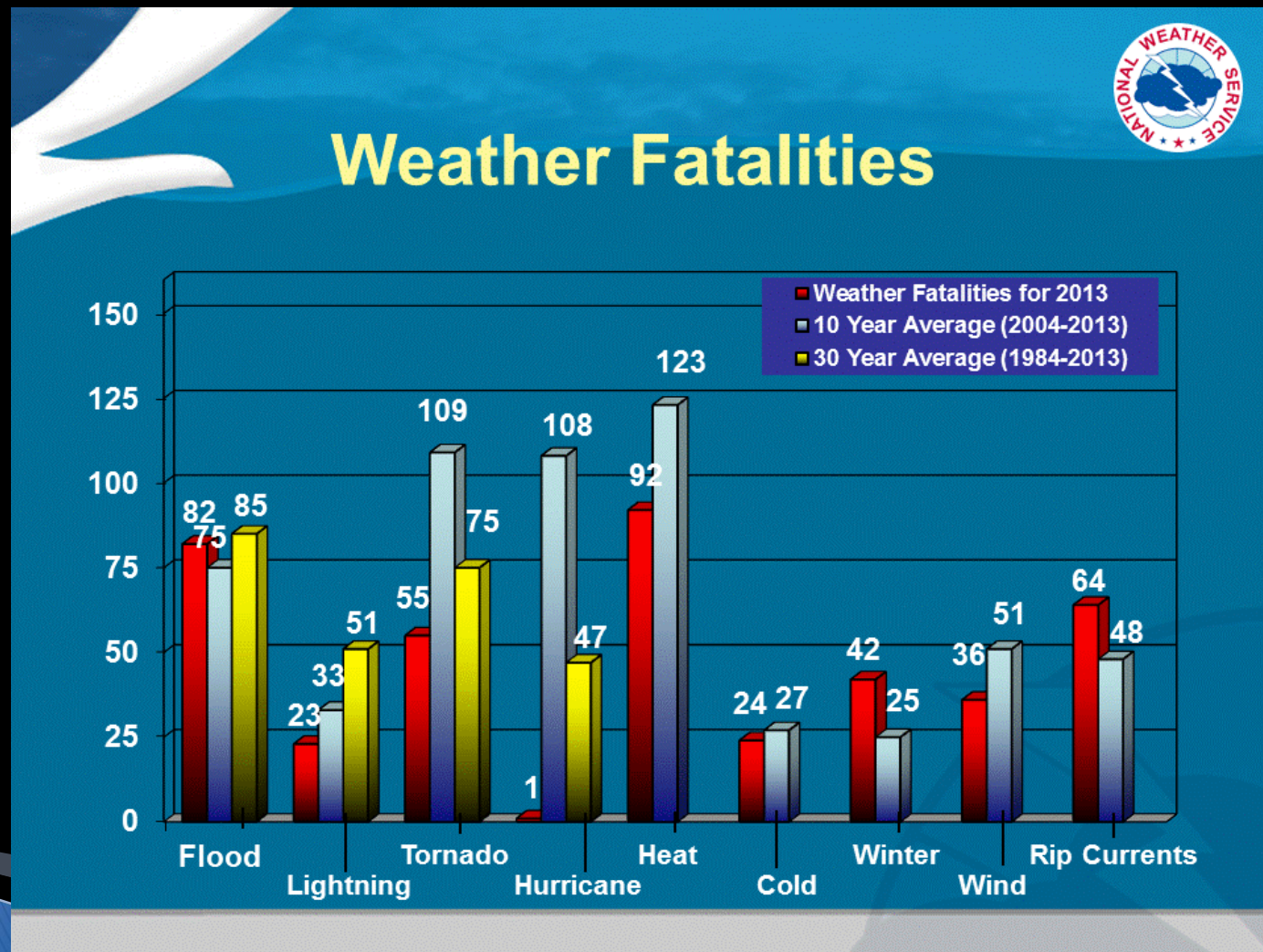
► River Forecast Centers

- Hydrologist-in-Charge
- Service Coordination Hydrologist
- Developmental & Operations Hydrologist
- 3 or 4 Hydrometeorologists
- 4 to 9 Hydrologists



Floods – a major weather killer

- ▶ On a long-term basis, floods are the #1 weather killer!



Flood Facts

- ▶ Most flood fatalities occur in cars
- ▶ Most flood fatalities occur at night
- ▶ Most flood fatalities can be avoided!!!



**Upper Marlboro, MD &
Fairfax, VA – Sept. 2011**



Flood Safety

- ▶ **Take Appropriate Action!**
- ▶ Better forecasts and earlier warnings won't help prevent loss of life and property unless people act.
- ▶ Plan ahead – Identify where to go if told to evacuate. Choose several places (a friend's home or a motel, or a designated shelter)
- ▶ Never try to drive, swim, walk, or run through a flooded area
- ▶ Children should not play in flooded areas

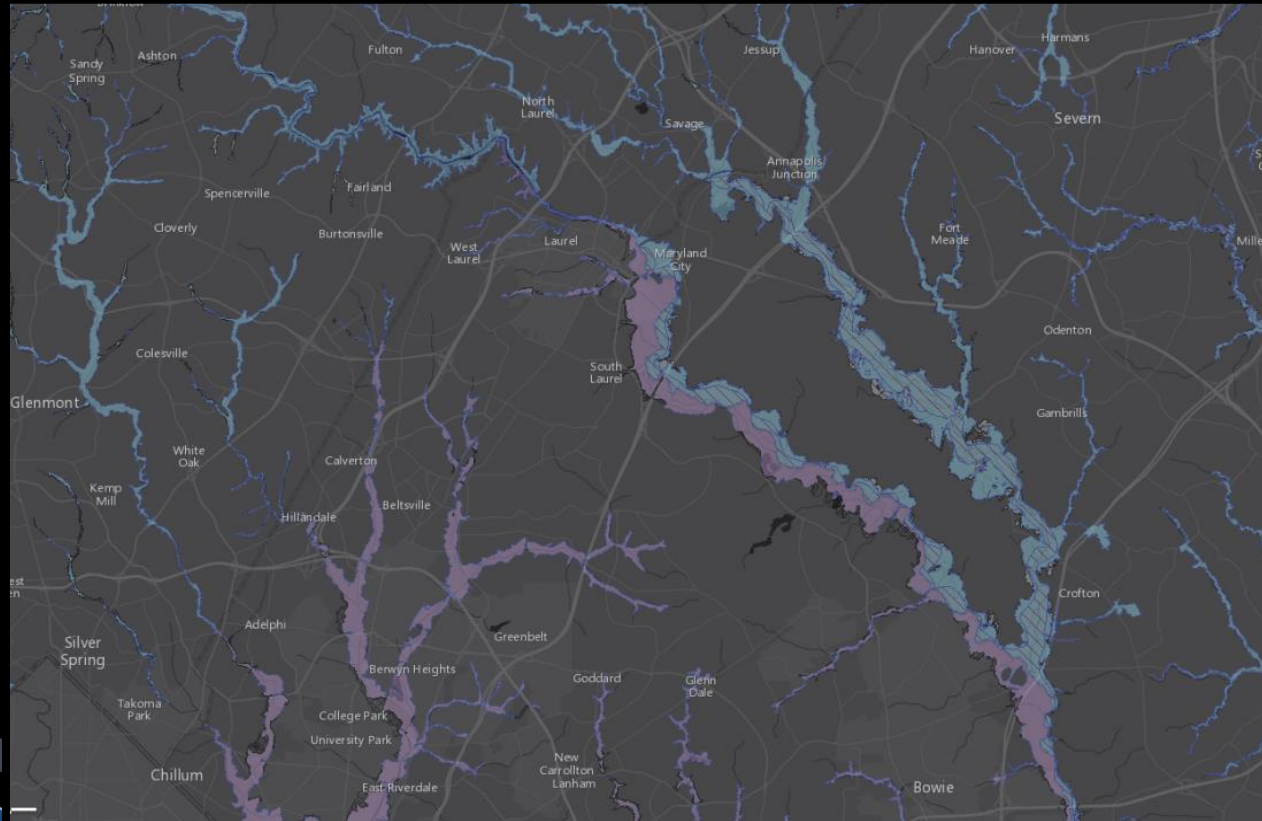


River Road, Falmouth, VA
March 2011



Know Your Risk

- ▶ **Check the FEMA Flood Maps to see if you are in a flood zone...**
 - <http://www.mdfloodmaps.net/dfirmimap/index.html>
 - <https://www.floodsmart.gov>
- ▶ **Flooding is not limited to these flood zones! Always consider flood insurance!**



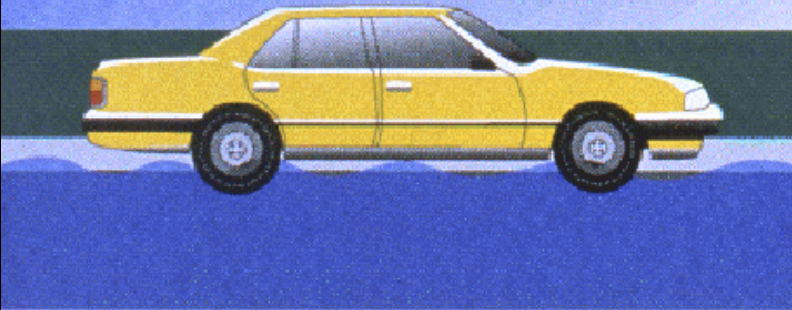
Turn Around, Don't Drown!

- ▶ If you come upon flood waters, **STOP! TURN AROUND AND GO ANOTHER WAY!**
- ▶ Only 6 inches of fast-moving water can knock you off your feet
- ▶ 2 feet of water will float an average size car...less water for smaller cars
- ▶ **Bottom line: never assume there is a safe way to drive through water**

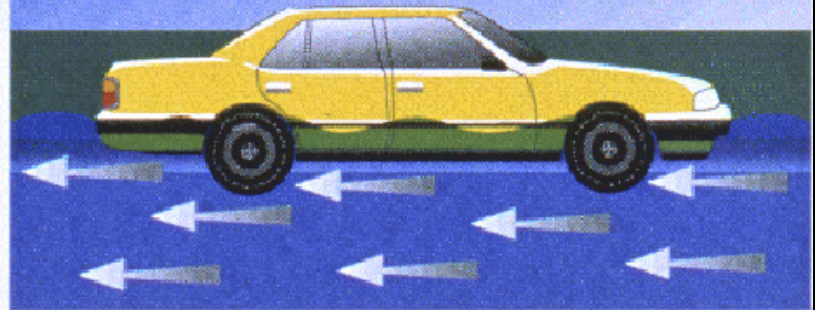


Turn Around, Don't Drown!

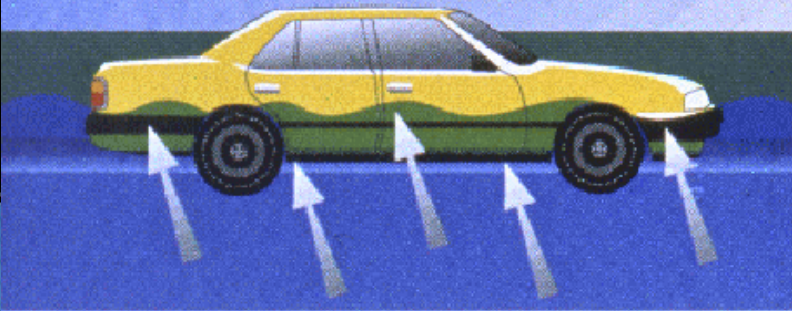
Water weighs 62.4 lbs per cubic foot and typically flows downstream at 6 to 12 mph.



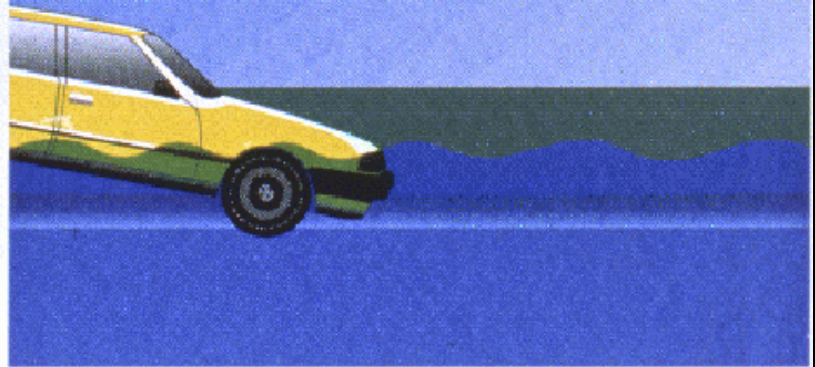
When a vehicle stalls in the water, the water's momentum is transferred to the car. For each foot the water rises, 500 lbs of lateral force are applied to the car.



The biggest factor is buoyancy. For each foot the water rises up the side of the car, the car displaces 1500 lbs of water. In effect, the car weighs 1500 lbs less for each foot the water rises.

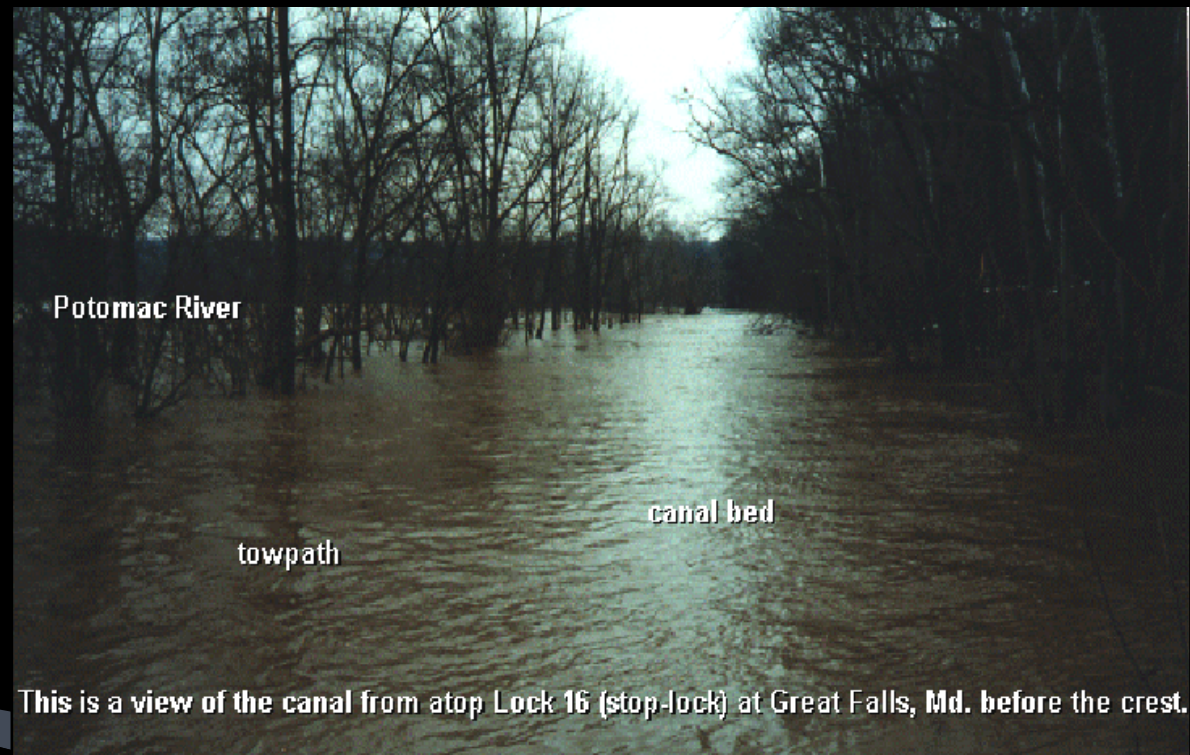


Two feet of water will carry away most automobiles!



Flood Damages

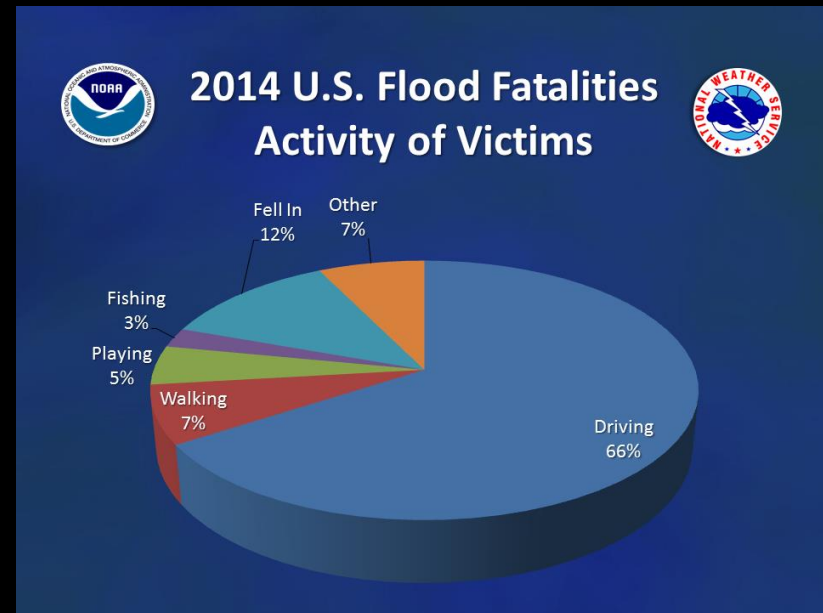
- ▶ Average: \$7.9 billion per year!
- ▶ 2014: \$2.9 billion
- ▶ In 2014, 2/3 of all Presidentially-declared disasters were at least in part flood-related



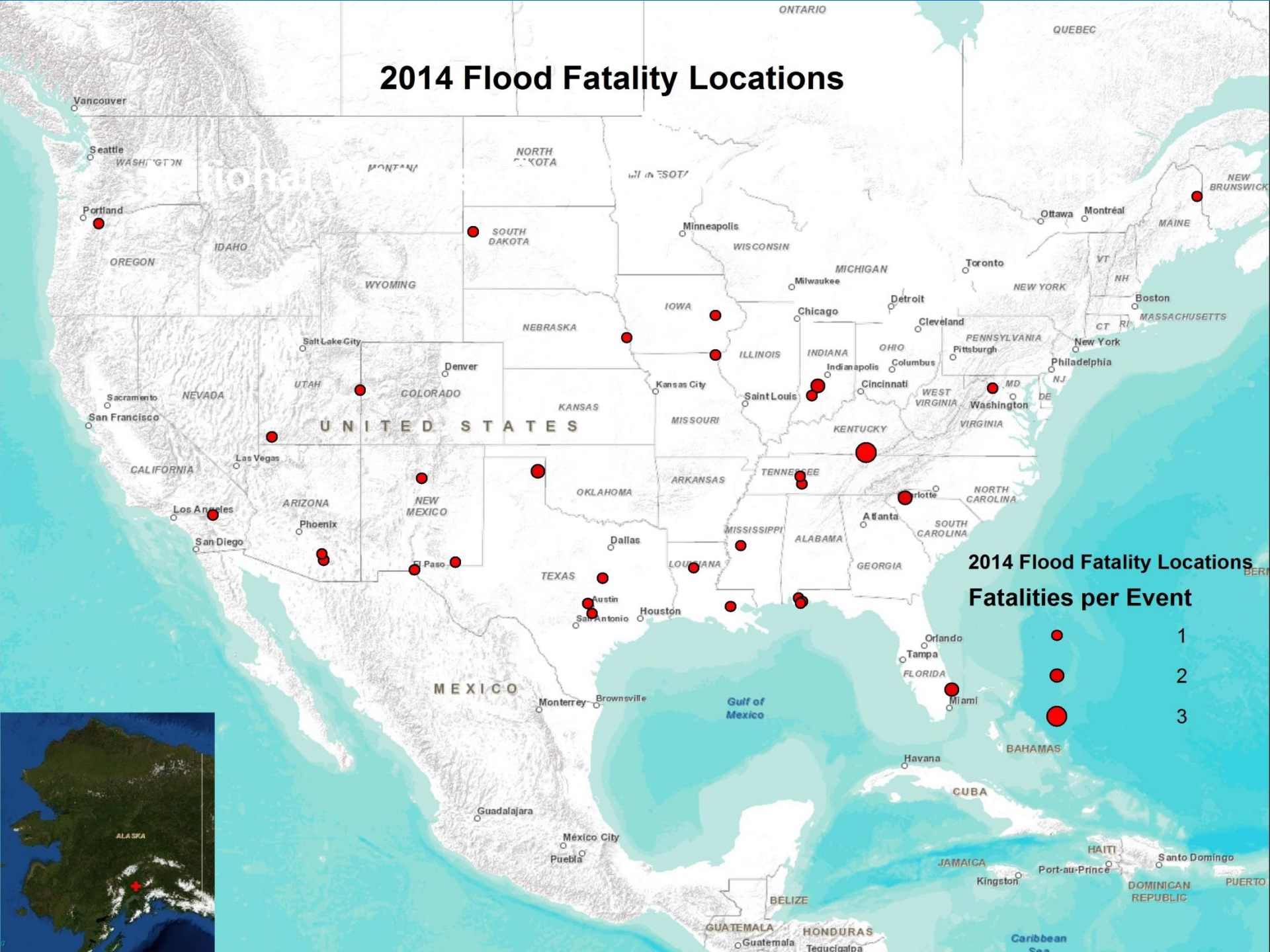
Great Falls, MD
1996

Flood Fatalities

- ▶ In 2014, there were 41 flood fatalities (only half of the long-term average).
 - No state had more than 6 (Texas)
 - One in our area
(Bryan Sears of Middletown, MD; Opequon Creek, VA)
- Of these, 27 (66%) were vehicle-related
- Other determined causes:
 - 5 fell into the water
 - 3 walking or hiking
 - 2 on horseback
 - 2 children playing in water
 - 1 boating
 - 1 on bridge when washed out

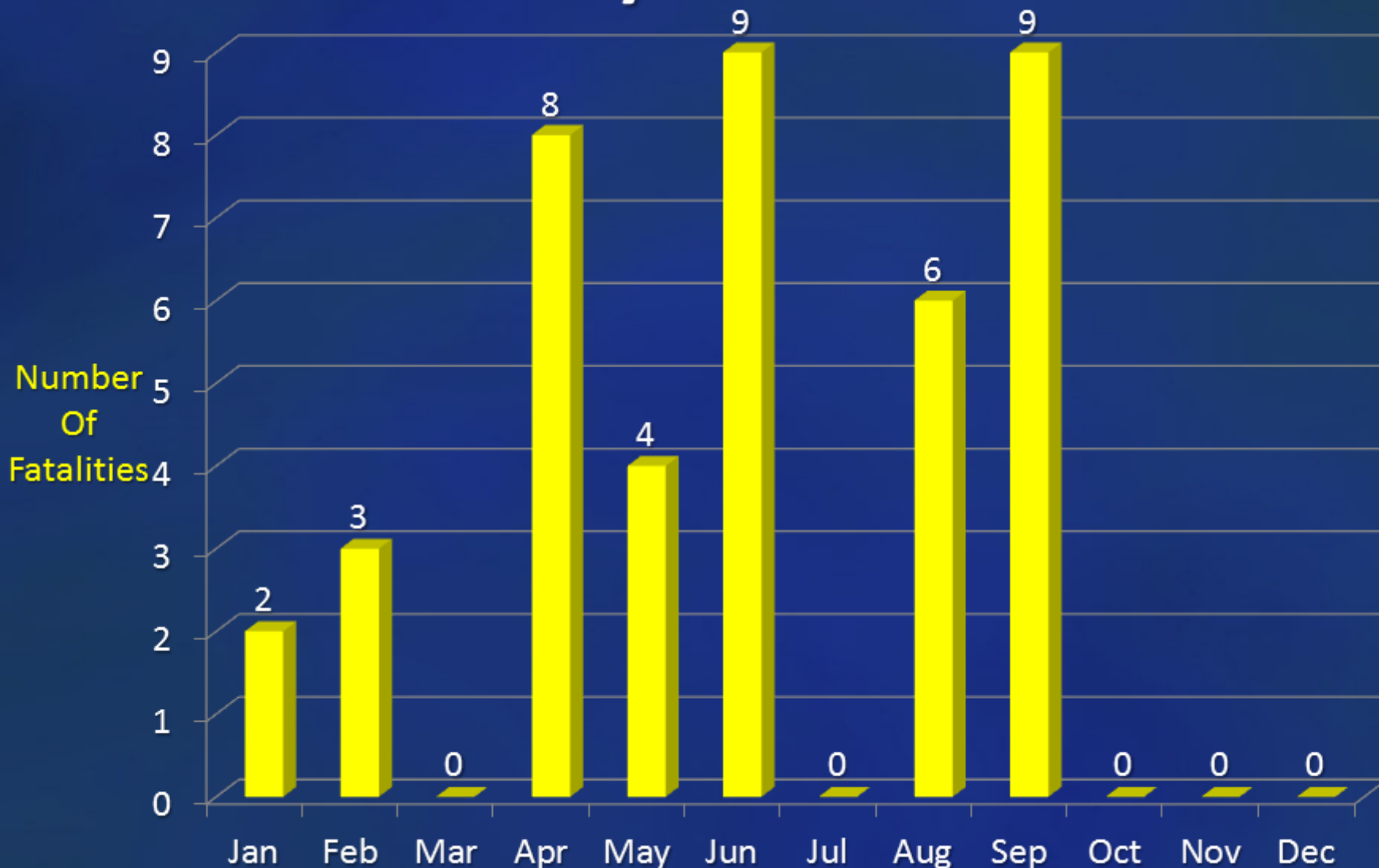


2014 Flood Fatality Locations

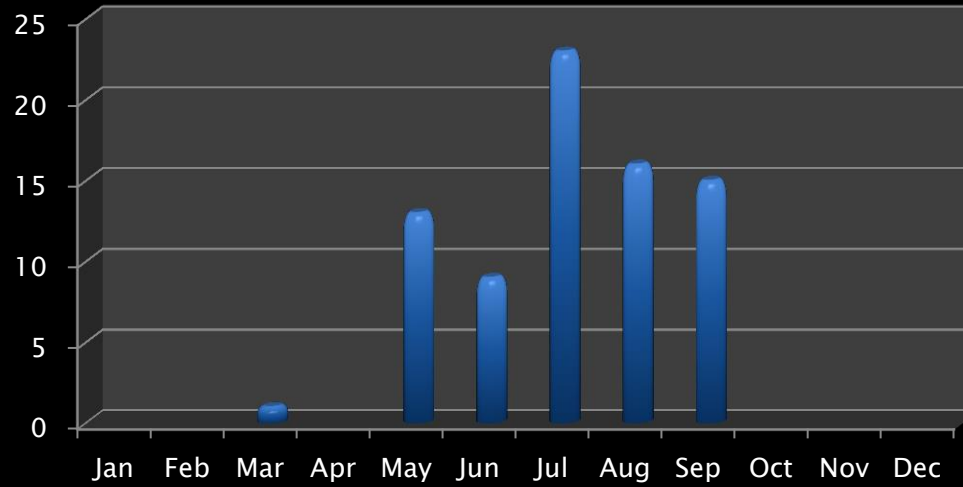




2014 U.S. Flood Fatalities By Month

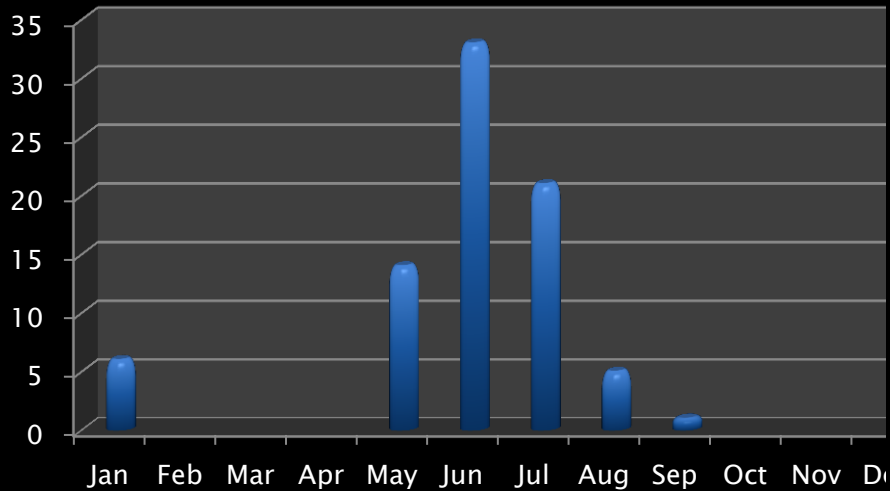


FFWs in 2012 by month



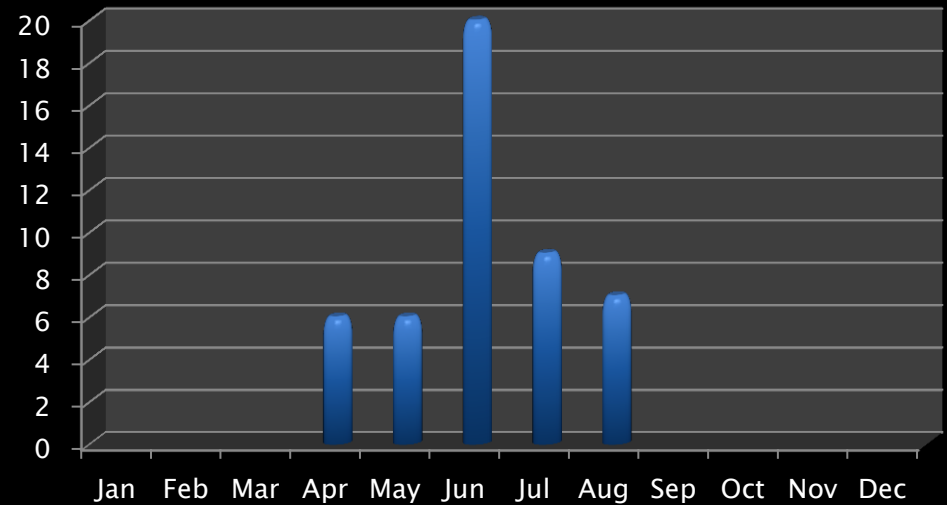
60% of warnings issued before July 31st

FFWs in 2013 by month



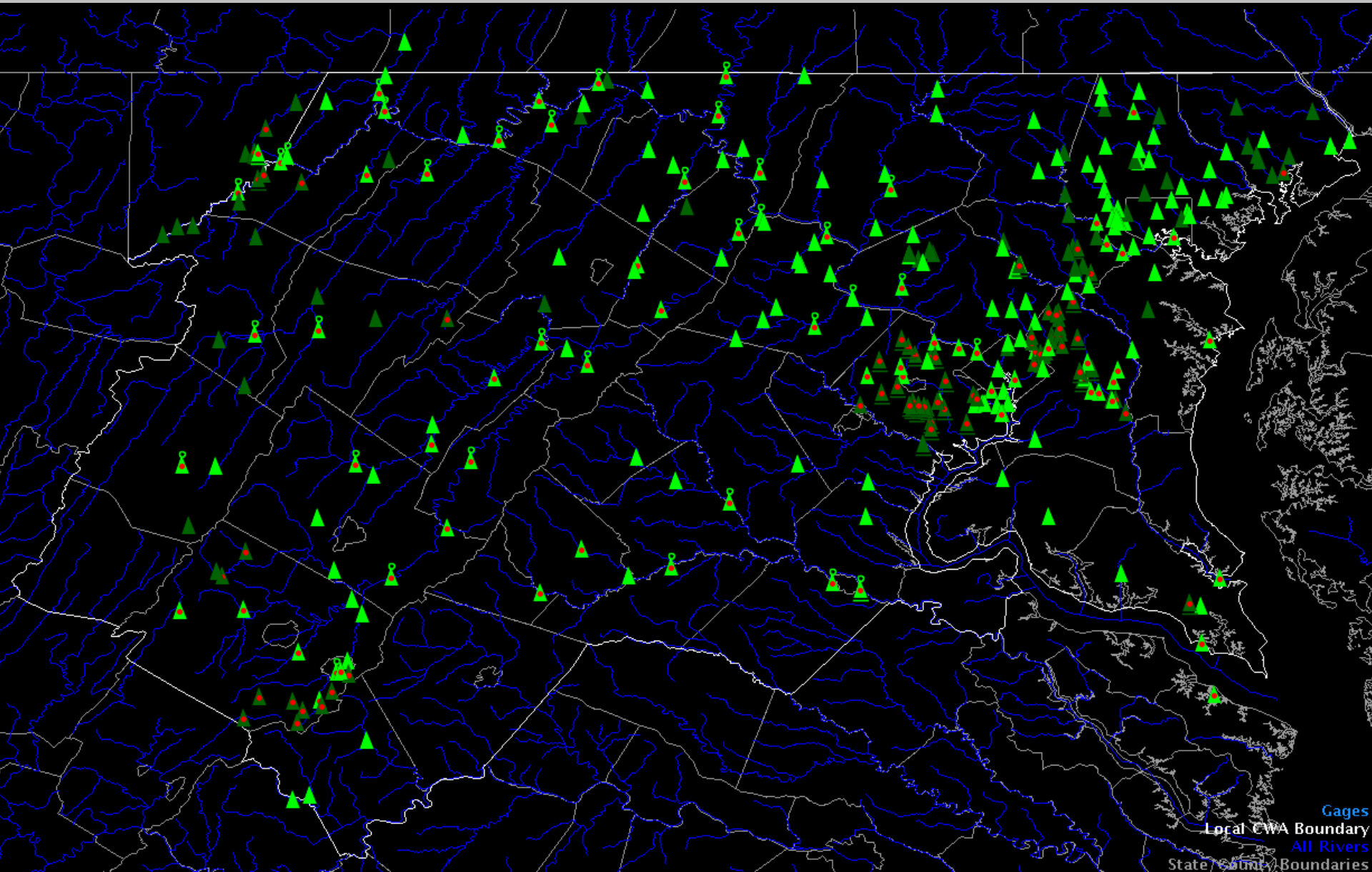
67% of warnings issued before June 30th

FFWs in 2014 by month

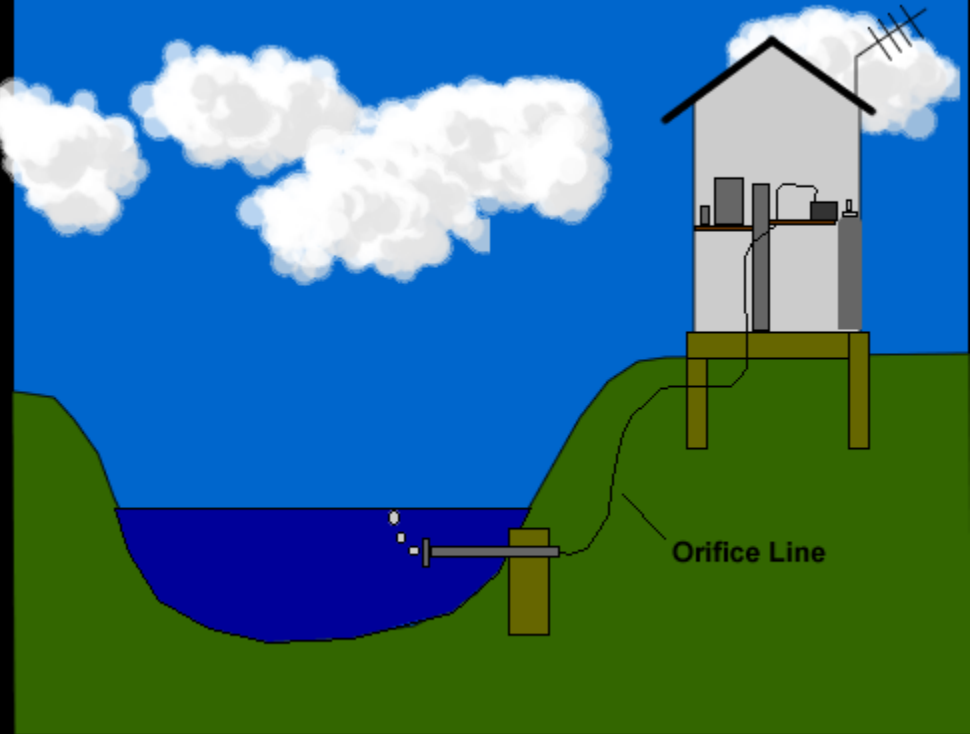
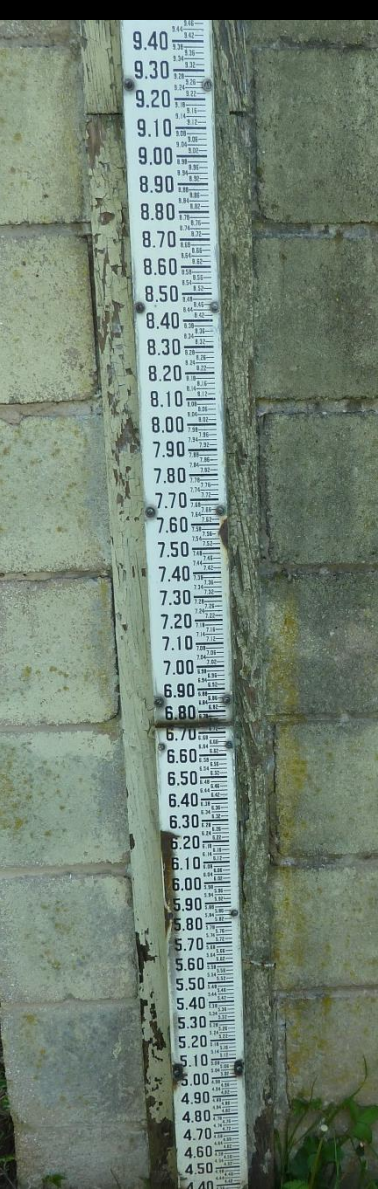


68% of warnings issued before June 30th

River & Lake Gauges

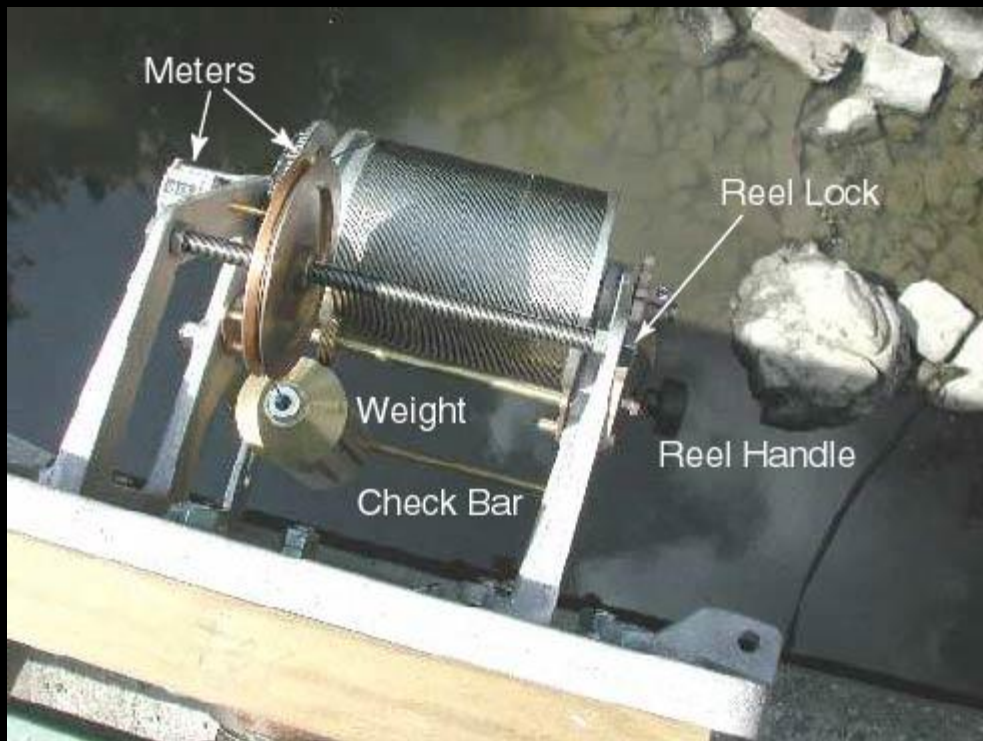


How are water levels measured?

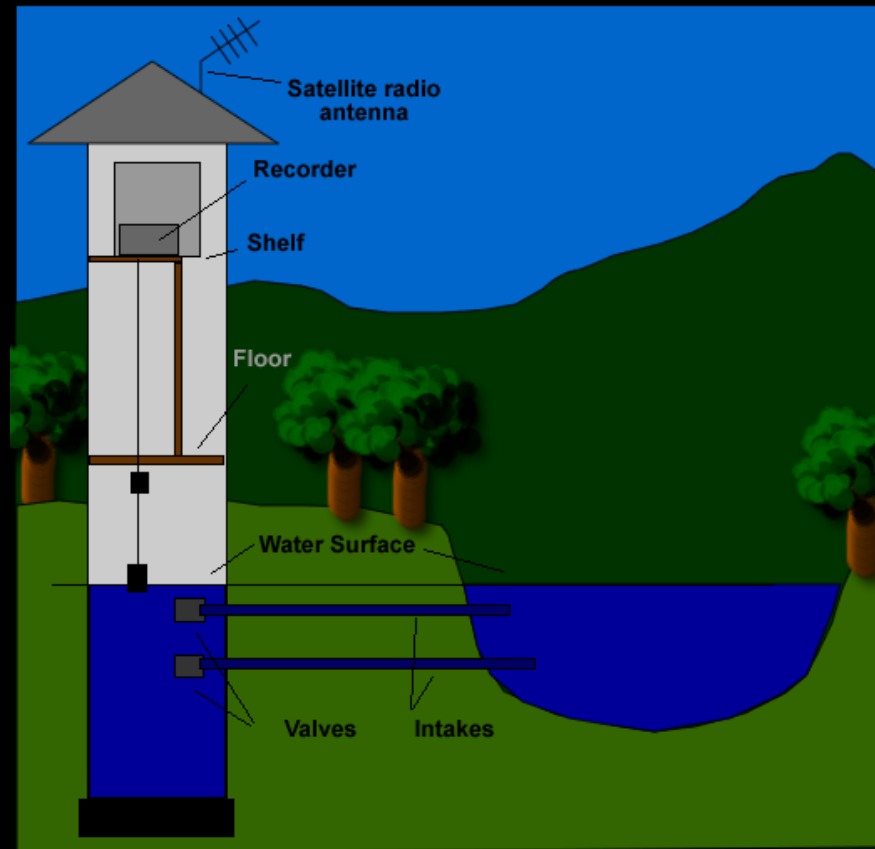


From left:
Staff Gauge
Crest Gauge
Radar Gauge
Pressure Transducer/Bubbler

How are water levels measured?



Wire Weight Gauge



Stilling Well / Float

What data do we receive?

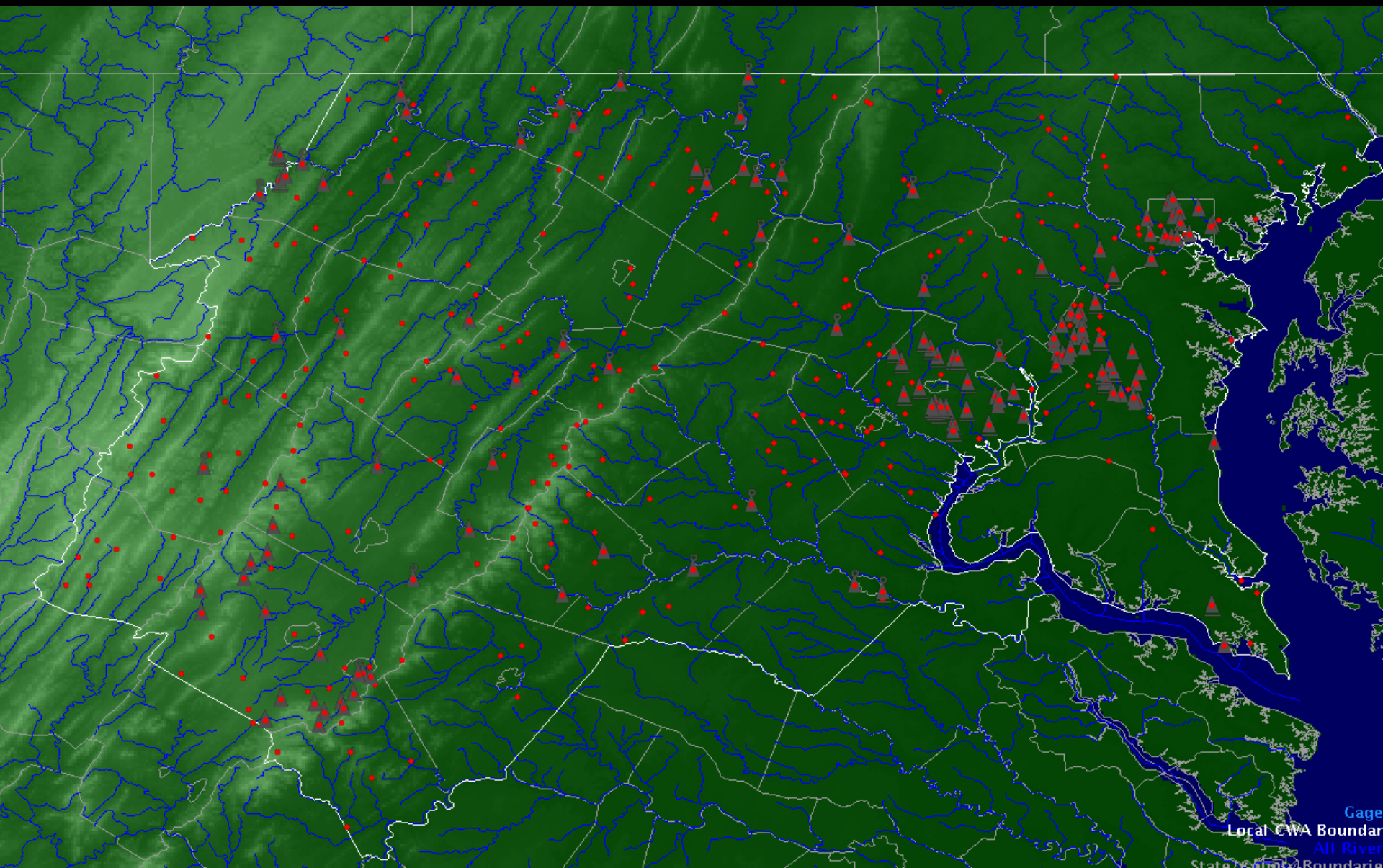
- ▶ 2/3 of gauges report by satellite
 - Receipt once per hour, but data can be 1-minute timescale
- ▶ 1/3 report by other methods
 - Telephone, manual reading, radio, web, etc.
- ▶ In addition to river stage, some automated gauges report:
 - Precipitation
 - Water temperature
 - Water quality elements
 - Air temperature
 - Wind speed/direction
 - Groundwater Level
 - ...and more!



Local River/Lake Network



Precipitation Monitoring

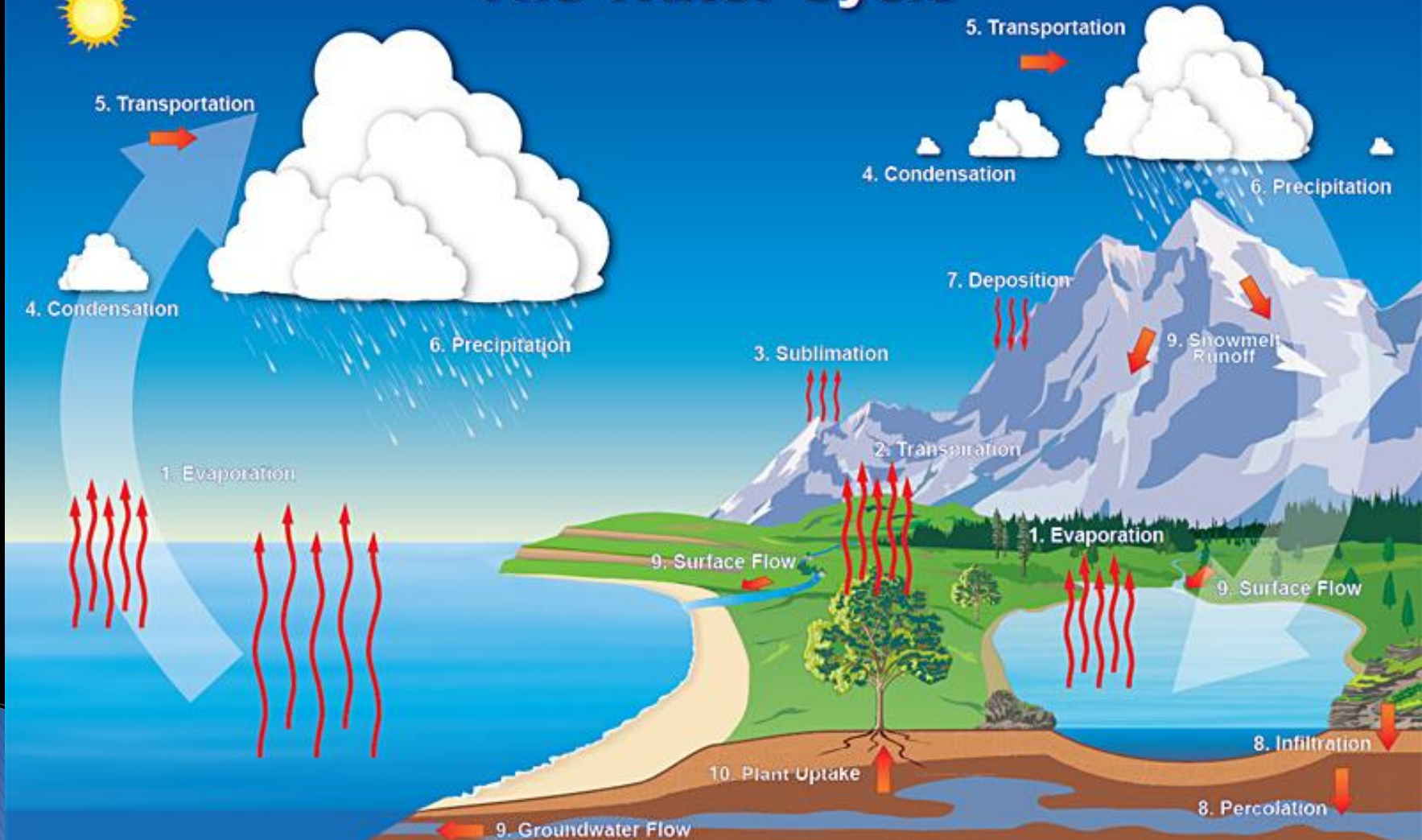


Local Precipitation Monitoring



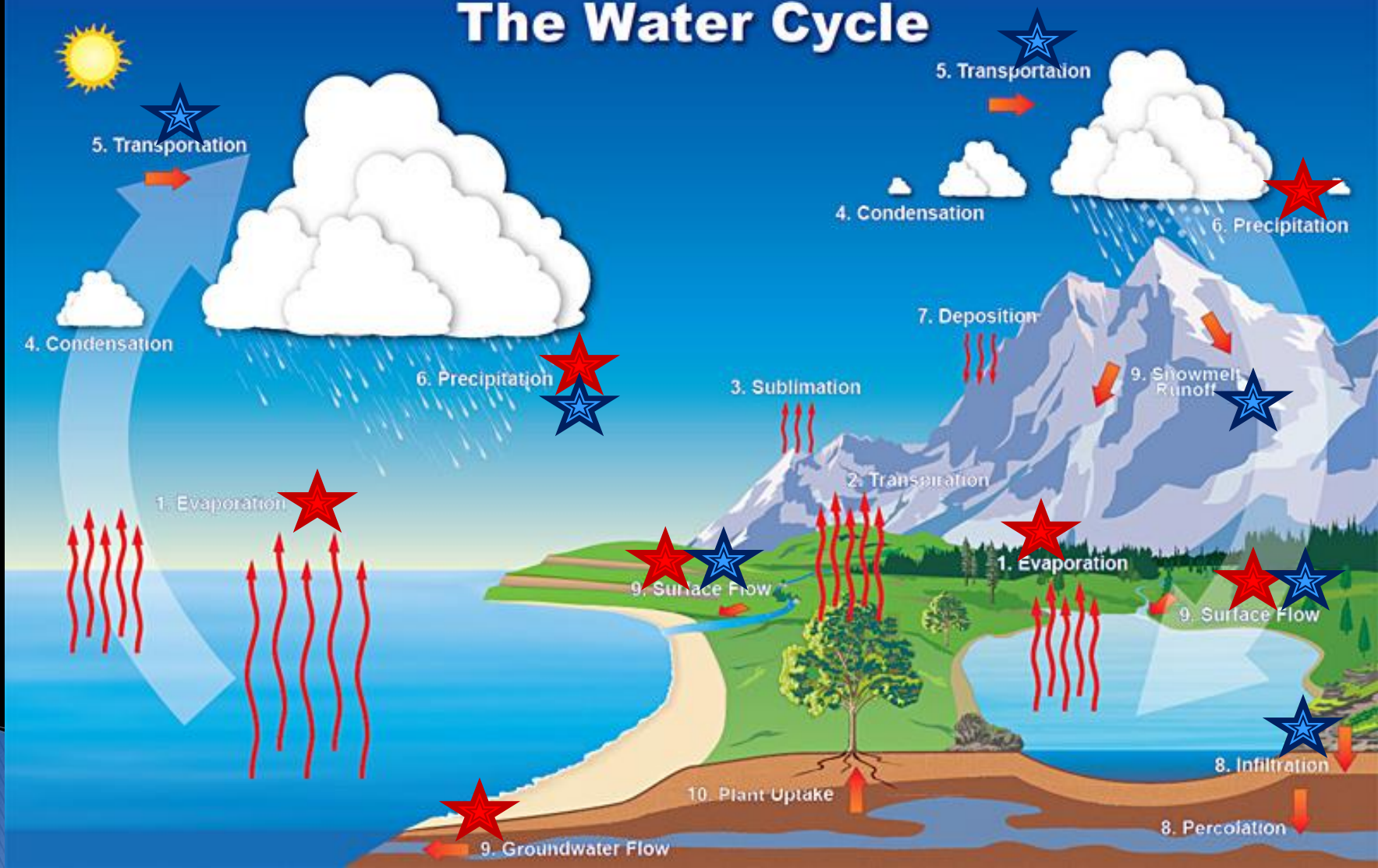
Basic Hydrology

The Water Cycle



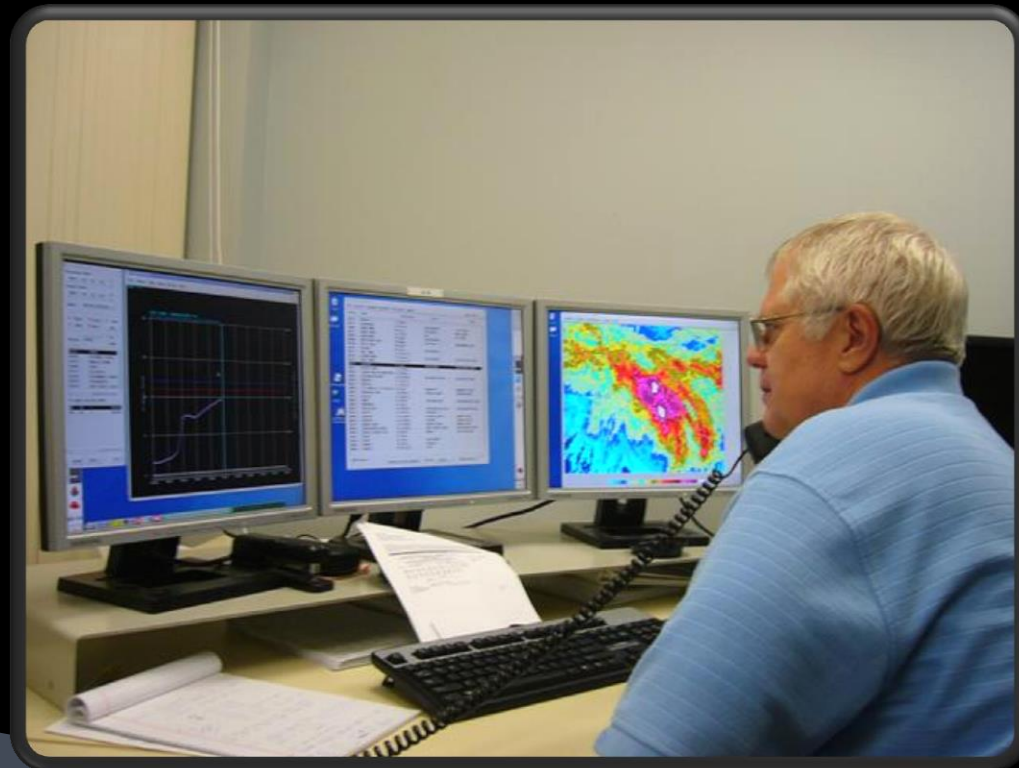
Basic Hydrology

The Water Cycle



How do we forecast flood potential?

- ▶ Pre-event assessment *“antecedent conditions”*
- ▶ Forecast expected rainfall
- ▶ Consider areas more prone to flooding
- ▶ Put it all together!



Pre-event assessment

Questions to ask / items to check:

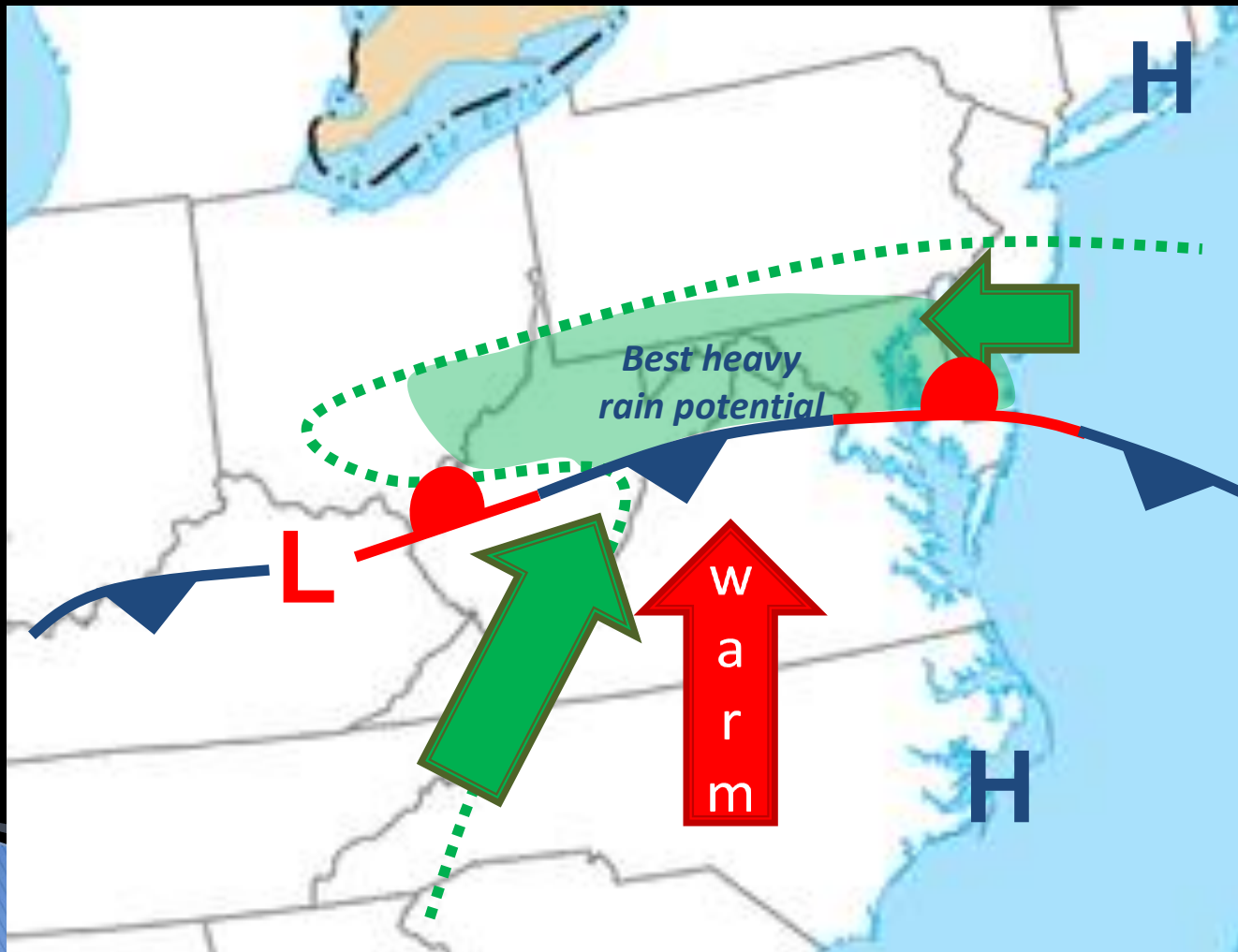
- ▶ Is the ground/soil wet or dry?
- ▶ What type of soil exists? (sandy, clay, frozen)
- ▶ Are streams at baseflow or elevated?
- ▶ What is the topography of the area?

- ▶ **More questions based on time of year**
 - Have the trees leafed out yet?
 - Is there snow on the ground? Will the snow melt?
 - Could plowed snow or fallen leaves clog drainage systems?



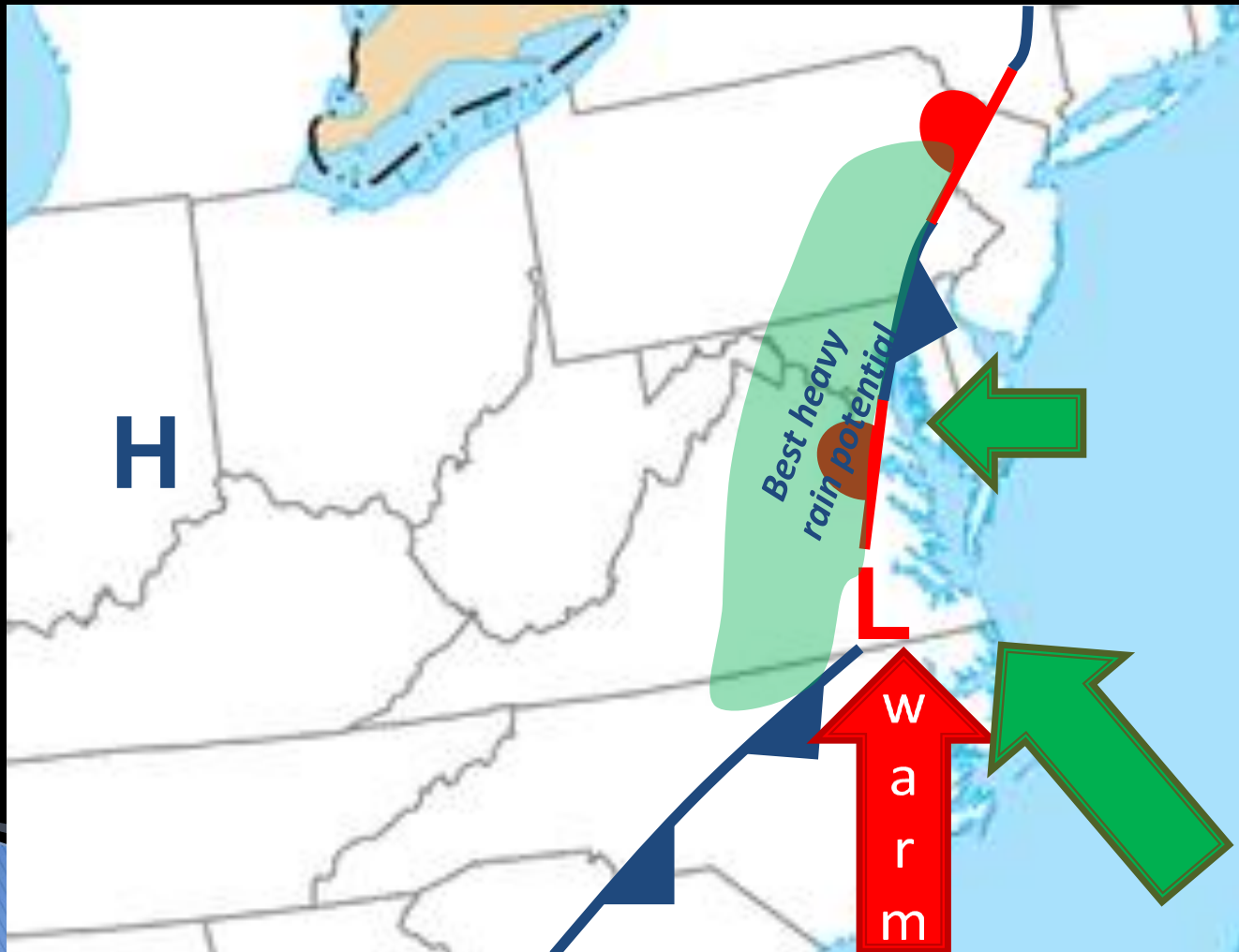
Favorable Weather Patterns

► Slow-moving or Stationary Fronts



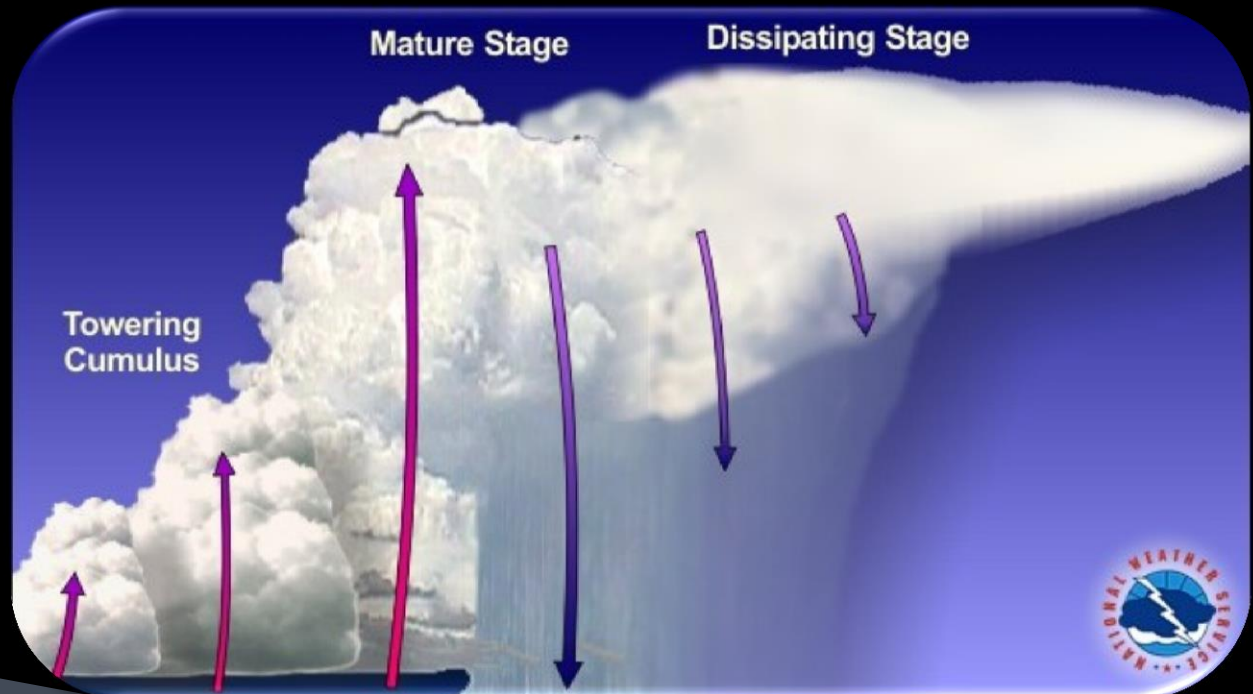
Favorable Weather Patterns

- ▶ Slow-moving or Stationary Fronts
(this could also be the sea breeze!)

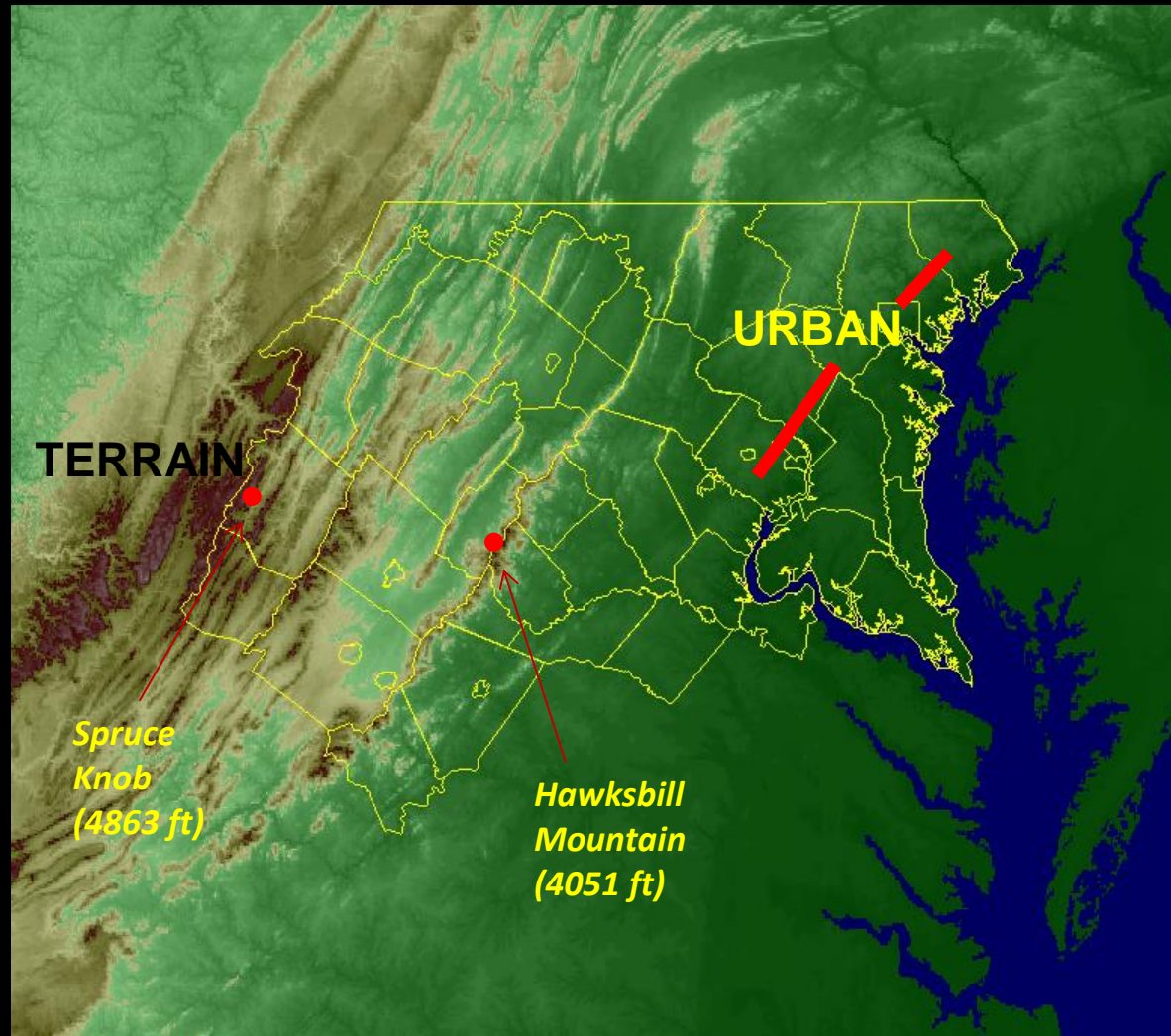


Favorable Weather Patterns

- ▶ High Moisture Content
 - Dewpoints & Precipitable Water
- ▶ Slow-moving & Training (Repeating) Thunderstorms



Areas Prone to Flooding

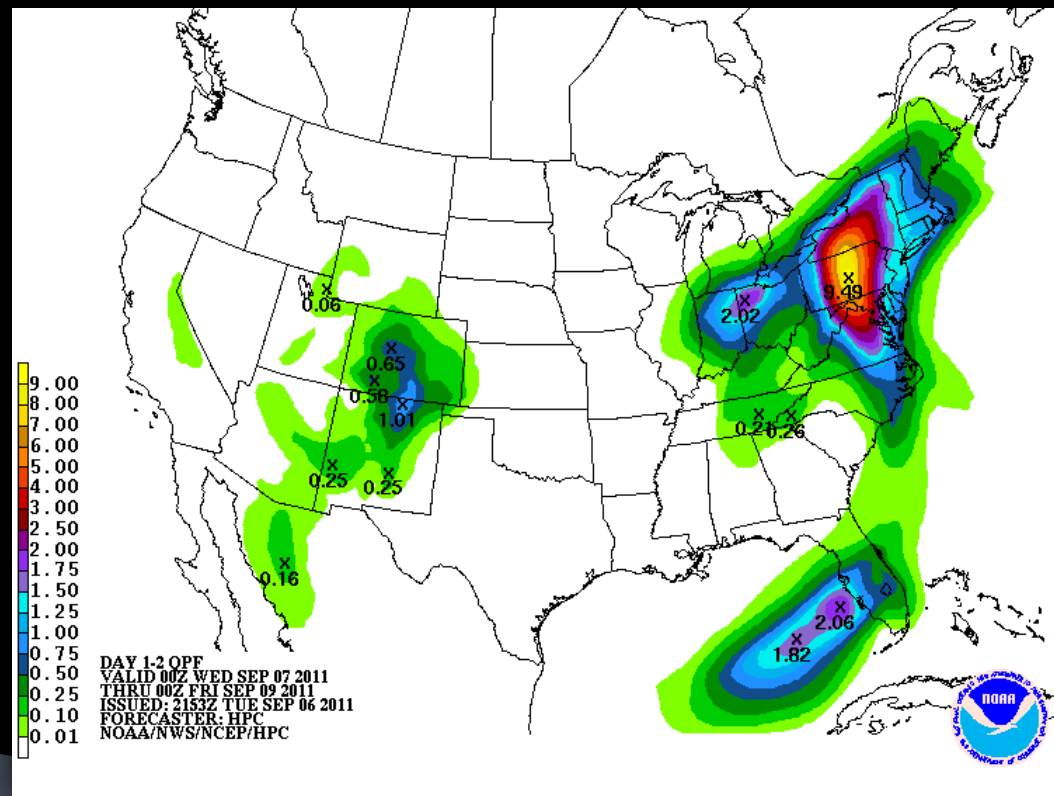


- ▶ Complex terrain and urbanization significantly enhance flood risk.



Making a Rainfall Forecast

- ▶ We begin with precipitation forecasts from the NWS Weather Prediction Center (WPC).
- ▶ Their forecasts are large-scale, so we localize them for the effects we just described.
 - (After all, we know rain doesn't fall in neat circles, right?)



Putting It All Together

- ▶ Once we have forecast the amount of rainfall expected...we have to combine this forecast with the antecedent conditions, as well as how quickly the rain is expected to fall.

Flood vs. Flash Flood



Flood vs. Flash Flood

- ▶ **Flash Flood** - a *rapid and extreme* flow of high water into a normally dry area, or a rapid water level rise in a stream or creek above a predetermined flood level, *beginning within six hours of the causative event* (e.g., intense rainfall, dam failure, ice jam). However, the actual time threshold may vary in different parts of the country. Ongoing flooding can intensify to flash flooding in cases where intense rainfall results in a rapid surge of rising flood waters.
- ▶ **Flood** - any high flow, overflow, or inundation by water which causes or threatens damage.

Source: NWS Instruction 10-950 dated November 20, 2012



What makes a flash flood?

- ▶ Typical Flash Flood Characteristics
 - Caused by convection (thunderstorms or intense showers)
 - More isolated compared to flooding
 - Response time is short, usually 1-2 hours, but as little as 15 mins. in urban areas (compared to 6-12 hours for flooding)
 - Swift Water Rescues, road closures (especially major roads), creeks and streams flood within an hour or two of the causative event
 - Occurs more frequently in urban areas and in terrain



**Flash Flood debris flow
near Front Royal, VA – 2011**



When does flash flooding occur?

- ▶ Can occur anytime – day or night.
- ▶ Approximately two-thirds of all flash flooding occurs at night.
- ▶ Most flash flood fatalities occur at night!
- ▶ Flash Flooding is NOT restricted to only mountainous areas.



C&O towpath breach at Old Anglers Inn (January 1996)

Location, Location, Location!

- ▶ Creeks
- ▶ Streams
- ▶ Ravines
- ▶ Washes
- ▶ Gullies
- ▶ Urbanized areas
- ▶ Underpasses
- ▶ Poor Drainage Areas



Flash Floods – What to Report

- ▶ River or stream flows out of banks and is a threat to life or property.
- ▶ Person or vehicle swept away by flowing water from runoff that inundates adjacent grounds.
- ▶ A maintained county or state road closed by high water.
- ▶ Approximately six inches or more of flowing water over a road or bridge.
 - This includes low water crossings in a heavy rain event that is more than localized (i.e., radar and observer reports indicate flooding in nearby locations) and poses a threat to life or property.

See water where it doesn't belong, but it doesn't meet these criteria? Report it anyway, but please don't call it a flood! Be as descriptive as you can when you report.



Flash Floods – What to Report

- ▶ Dam break or ice jam release causes dangerous out of bank stream flows or inundates normally dry areas creating a hazard to life or property.
- ▶ Any amount of water in contact, flowing into or causing damage of an above ground residence or public building and is runoff from adjacent grounds.
- ▶ Three feet or more of ponded water that poses a threat to life or property.
- ▶ Mud or rock slide caused by rainfall (could possibly occur in a burned area with only light-moderate rainfall).

See water where it doesn't belong, but it doesn't meet these criteria? Report it anyway, but please don't call it a flood! Be as descriptive as you can when you report.



Special Cases – Debris Jams

- ▶ Occasionally, floating debris or ice can accumulate at a natural or man-made obstruction and restrict the flow of water.
- ▶ Water held back by the ice jam or debris dam can cause flooding upstream.
- ▶ Subsequent flash flooding can occur downstream if the obstruction should suddenly release.



Special Cases – Ice Jams



Chunks of ice collect in river channels and may ultimately stop the flow of water.

Ice can collect at a bridge and create an ice jam.

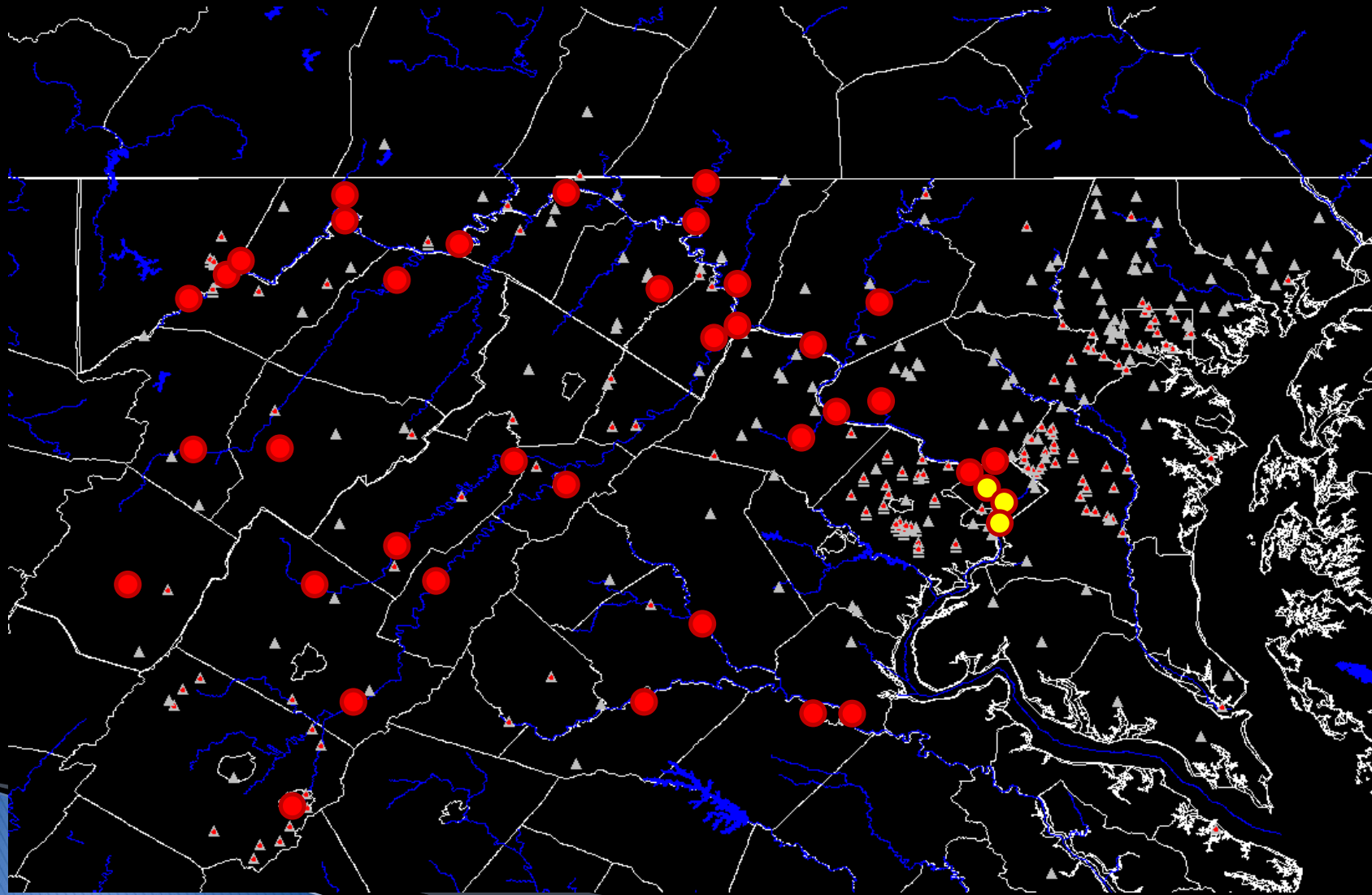
Water backs up behind the ice jam and subsequent flooding results.

What's this “Areal” Flood?

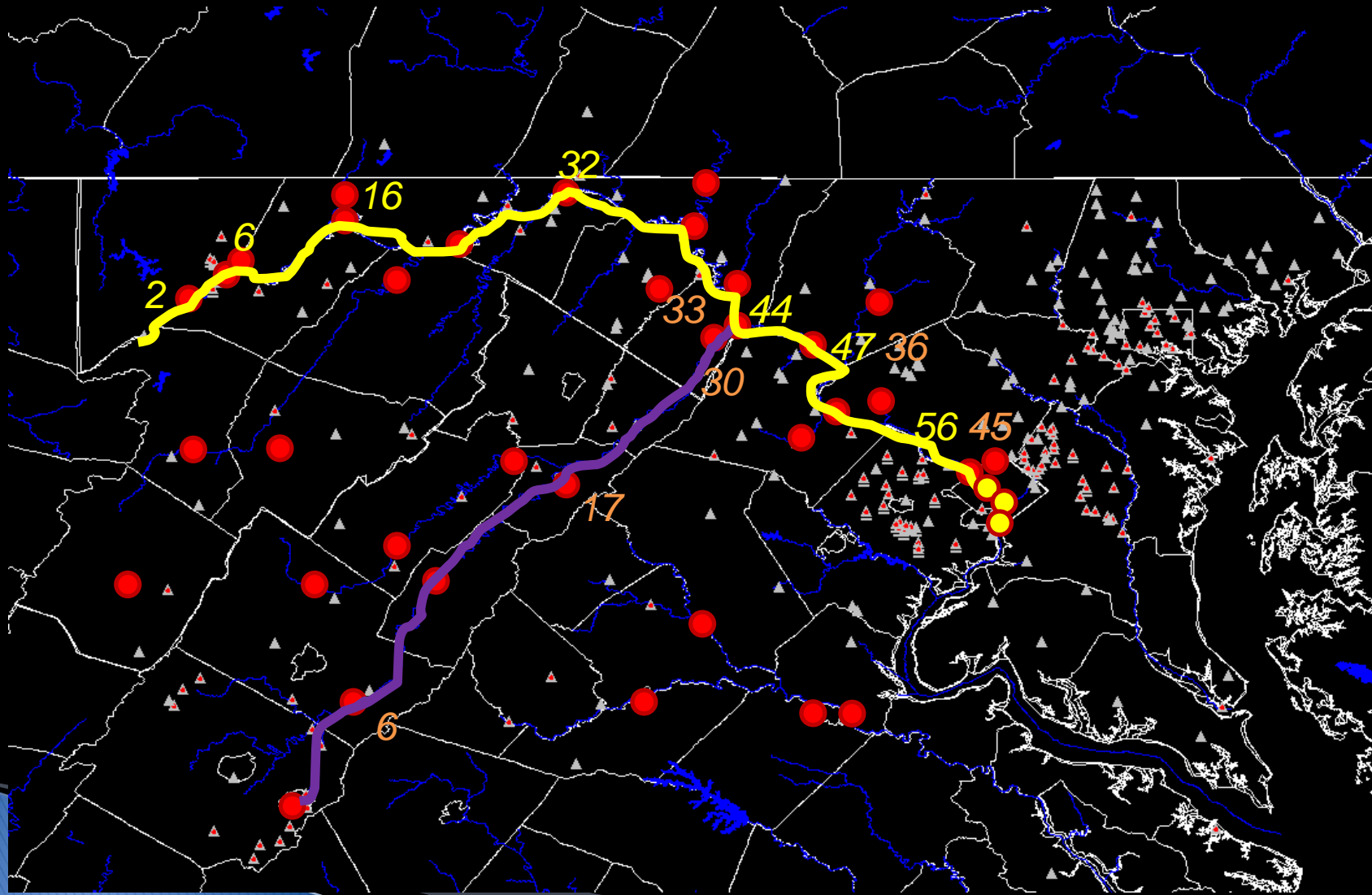
- ▶ **NOT** = “a real” flood
- ▶ **NOT** = “aerial” flood
- ▶ Flooding that covers an area.
- ▶ Flash Flooding typically affects a *very* small area. Areal flooding is slower to develop (> 6 hours) and usually affects a larger area.
- ▶ But...other than the time constraint, the “what to report” is exactly the same.
 - *(We'll go over it again in the second half of the presentation.)*



River Flood Forecast Points



Travel Times (in hours)



Coastal Flooding

- ▶ Prolonged onshore flow
- ▶ Storm Surge from Tropical Systems
- ▶ King Tides: the highest tides of the lunar season, around **new moon** when the Earth, Moon and Sun are aligned
- ▶ Next king tides: mid-June



Annapolis, MD – 2003



http://www.dnr.state.md.us/coastsmart/king_tide.asp

Coastal Flooding

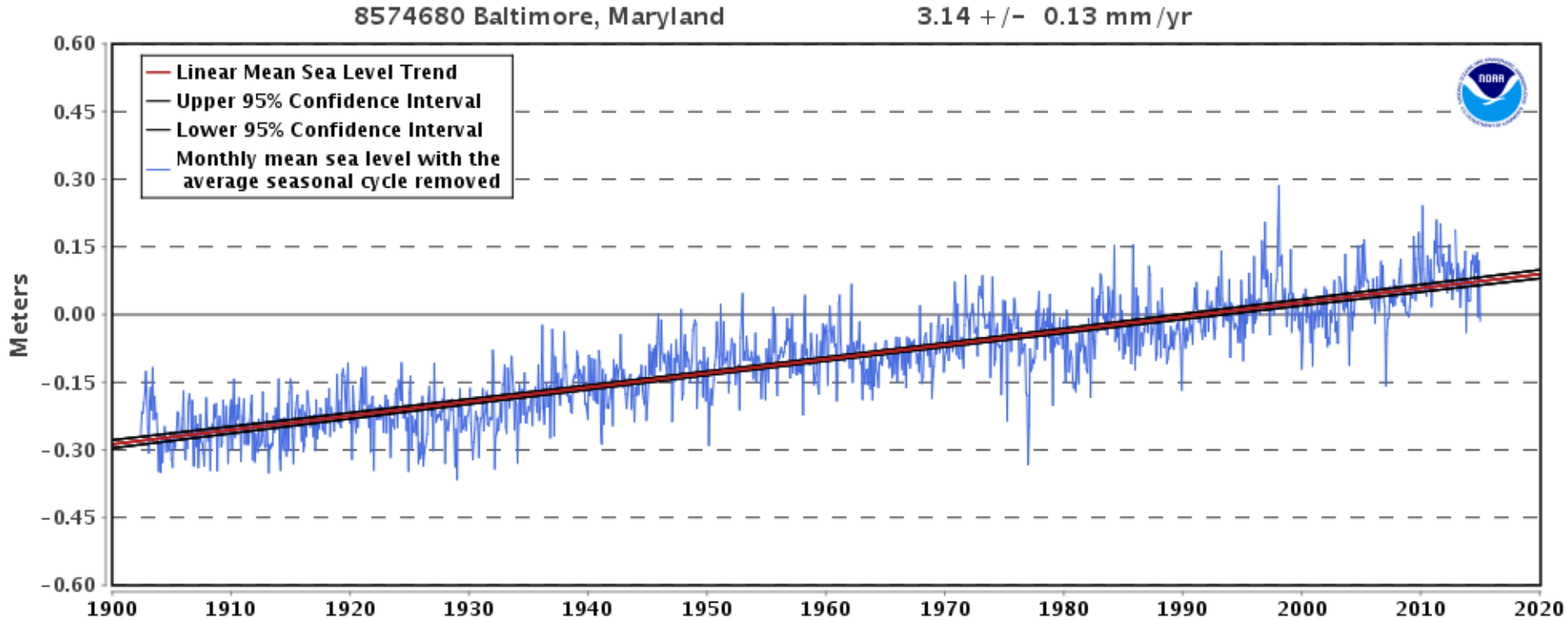
- ▶ Two distinct peaks for positive departures
April/May & September/October
- ▶ September stands out due to tropical systems

Minor Coastal Flooding at the US Naval Academy June 2005



On the Rise

- ▶ Mean Sea Level (MSL) is steadily rising...
(average rate ~ 1 foot/century)



More of a Nuisance

- ▶ A NOAA study finds that nuisance flooding (defined as reaching our NWS 'minor flood' level) has substantially increased in the last 50 years.
 - This is due to a rise in the base water level, not due to increased storms.

City	Average nuisance flood days (1957-63)	Average nuisance flood days (2007-13)	Percent increase
Annapolis	3.8	39.3	925%
Baltimore	1.3	13.1	922%
Washington	6.3	29.7	373%

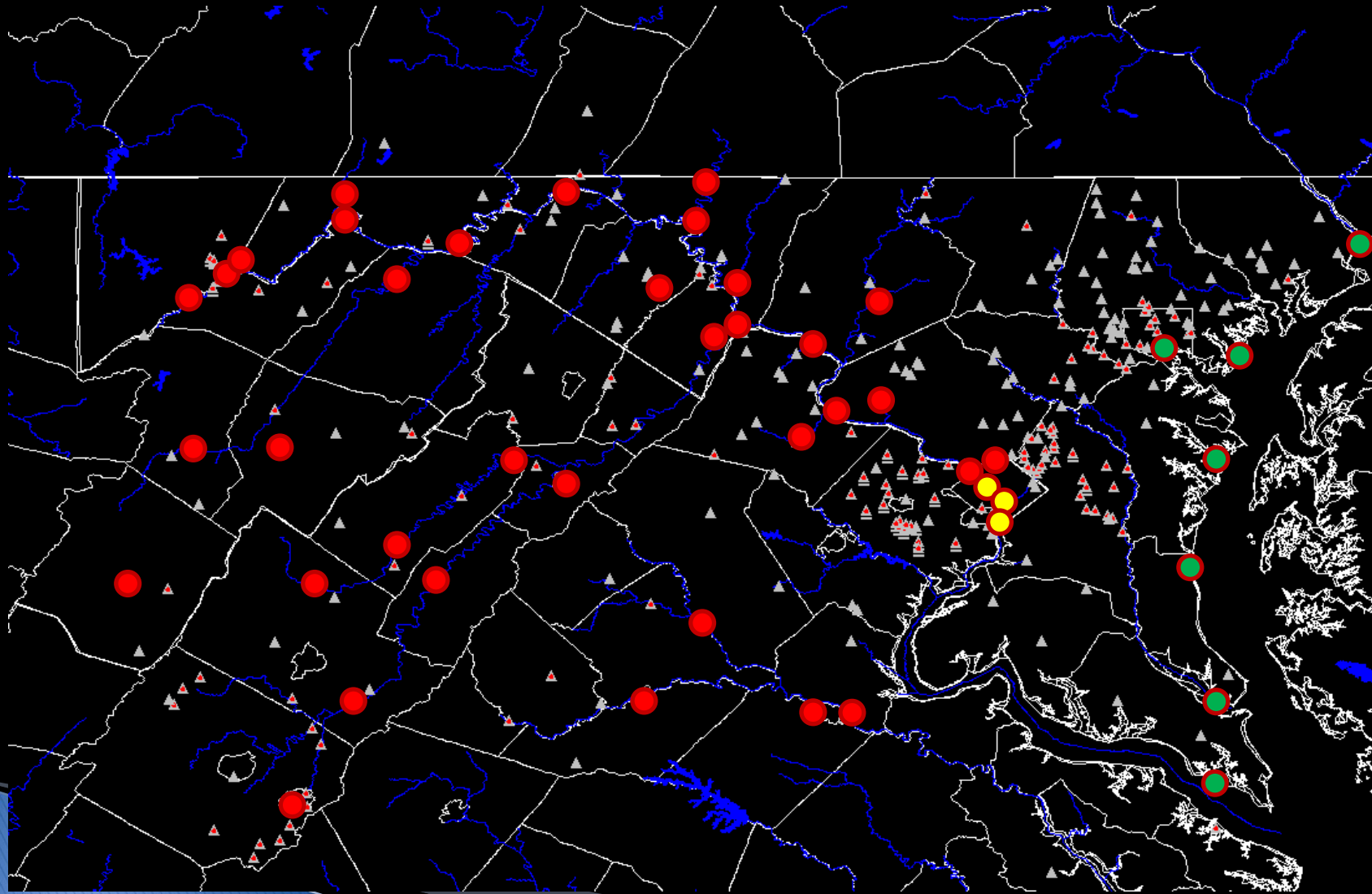


Weather Plays a Role

- ▶ During strong El Niño patterns, there was a much higher incidence of days with storm surge > 1 foot, and higher mean sea level along the Mid-Atlantic Coast.
 - *Sweet and Zervas (2011)*
- ▶ Recent years with stronger El Niño:
 - Late 2009 – Early 2010 (1.6)
 - 1997 – Early 1998 (2.4)
 - 1991 – 1992 (1.6)
 - 1982 – 1983 (2.2)
 - 1972 – Early 1973 (2.1)
- ▶ Although we are currently in a weak El Niño, strong El Niño conditions are not currently expected.



Flood Forecast Points



Break time!

Please return in 5 minutes



Our Products

Outlook

- Hazardous Weather Outlook
- Days 3 - 7

Watch

- Flood/Flash Flood/River Flood Watch
- Up to 48 hours (up to 72 for rivers)

Warning

- Flood/Flash Flood/River Flood Warning
- Occurring or imminent



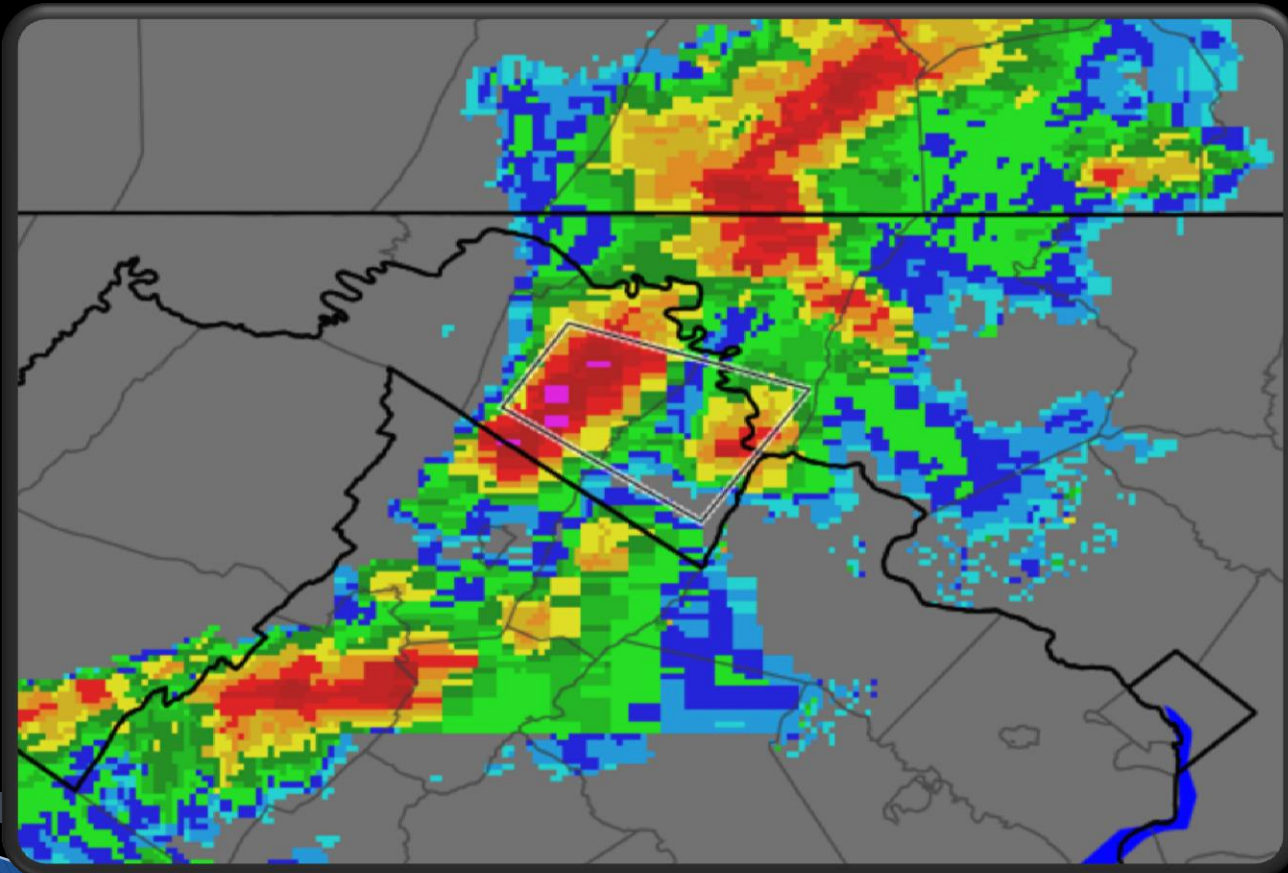
Watch vs. Warning

- ▶ **WATCH:** Conditions are favorable for flooding to occur (>50% chance). Be alert for possible flooding during the watch period.
- ▶ **WARNING:** Flooding is occurring or is extremely likely to occur (>75% chance). Stay out of low areas and seek higher ground if necessary!
- ▶ Note: A watch does not necessarily precede a warning, especially for river flooding.



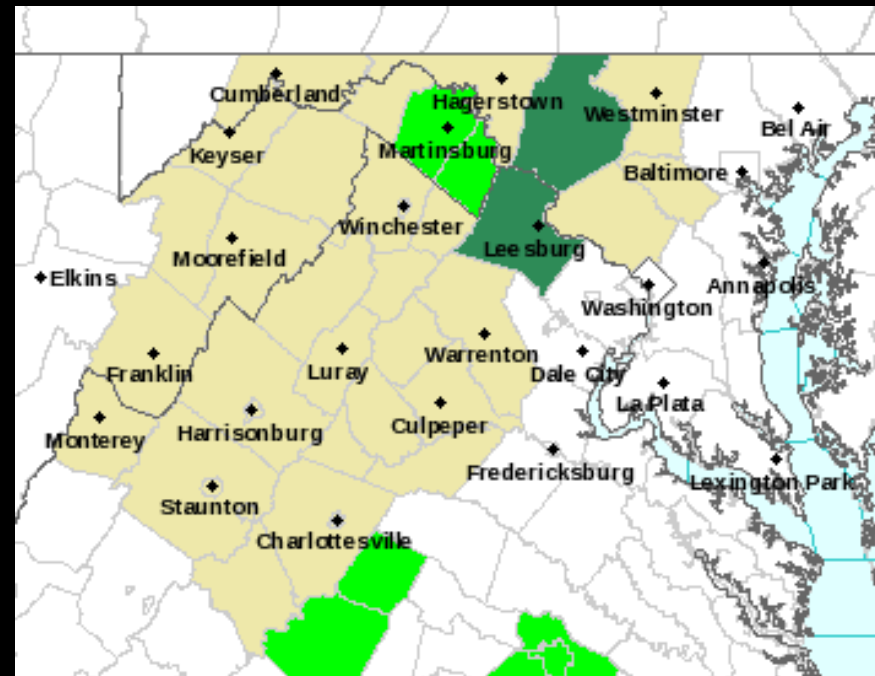
Basin-Based Warnings

- ▶ Our goal is to warn for:
 - Where the rain is going to go
 - Where the water is going to flow
- ▶ This means we may warn for places where it will not even rain!



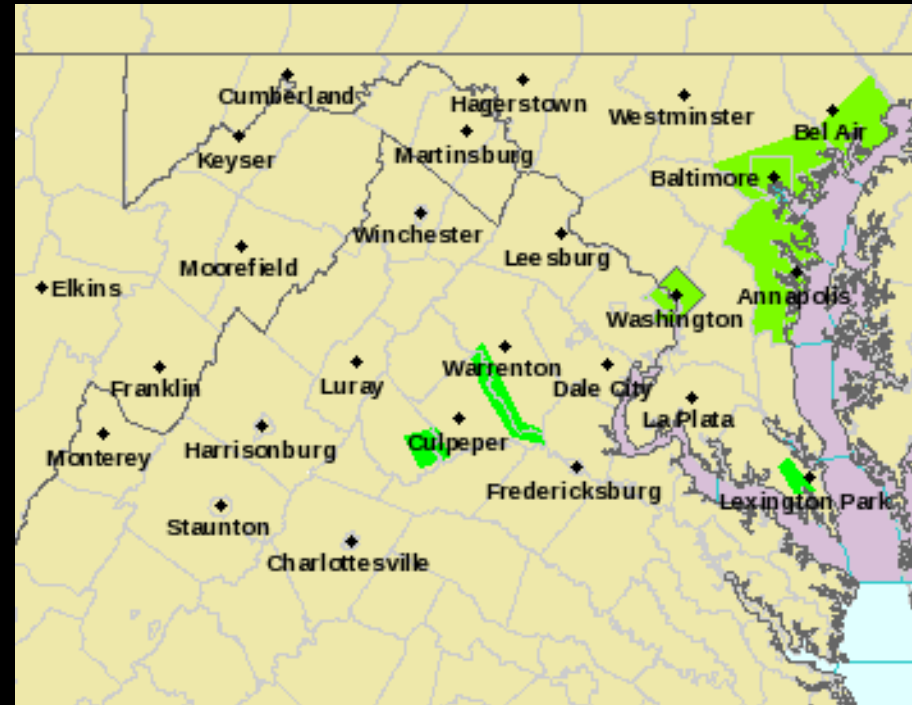
River Flood Watch/Warnings

- ▶ In 2011, we began issuing river flood watches for our designated forecast points
 - Issued when:
 - River Forecast reaches flood stage, but there is uncertainty about that forecast
 - River Forecast does not reach flood stage, but is close and a little more rain could put the river over
 - >50% confidence of reaching flood
 - Successful in lessening unnecessary warnings



River Flood Watch/Warnings

- ▶ In 2014, we began issuing river flood watches and warnings via polygons for designated forecast points
 - Limits the area covered by a watch or warning
 - Matches flash flood warnings and areal flood warnings which are already issued by polygon

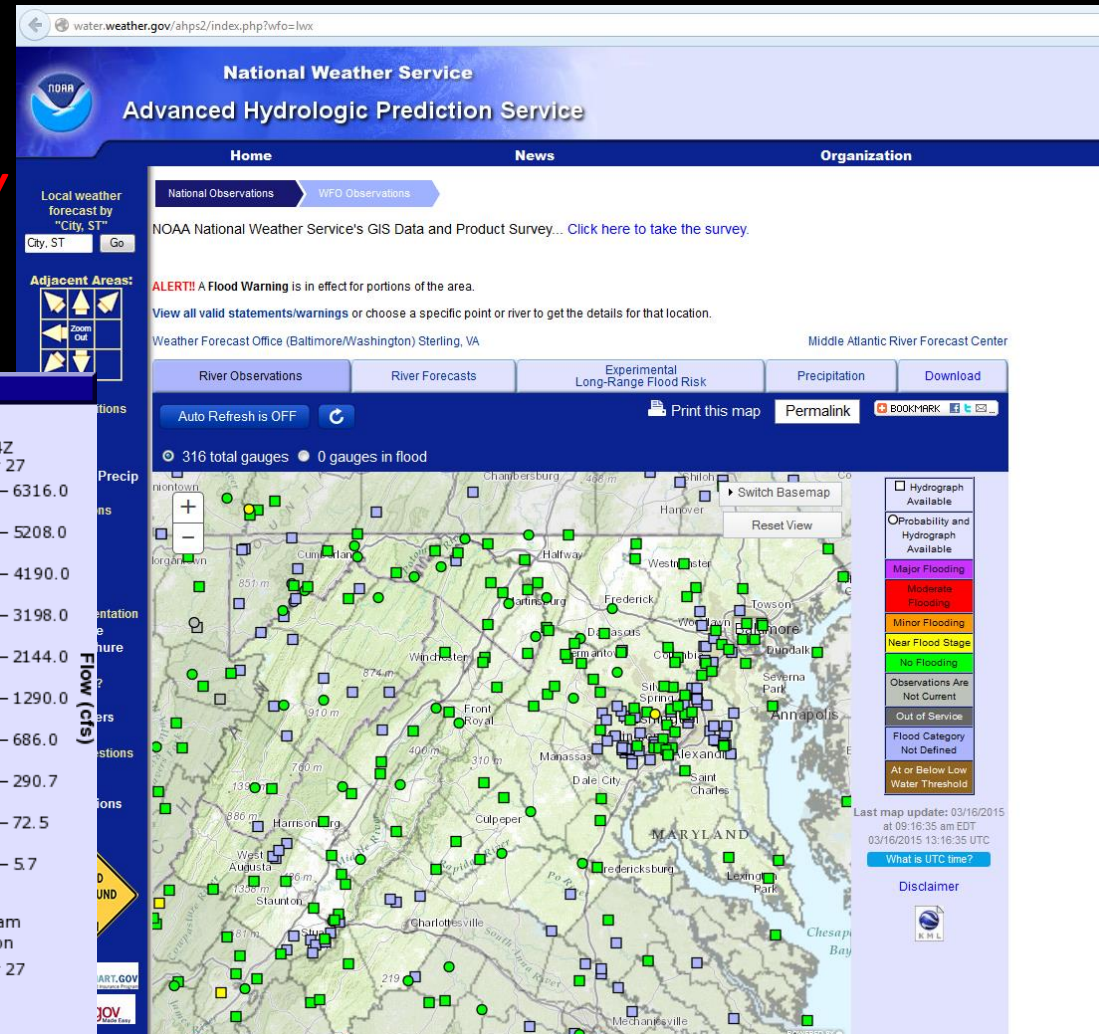
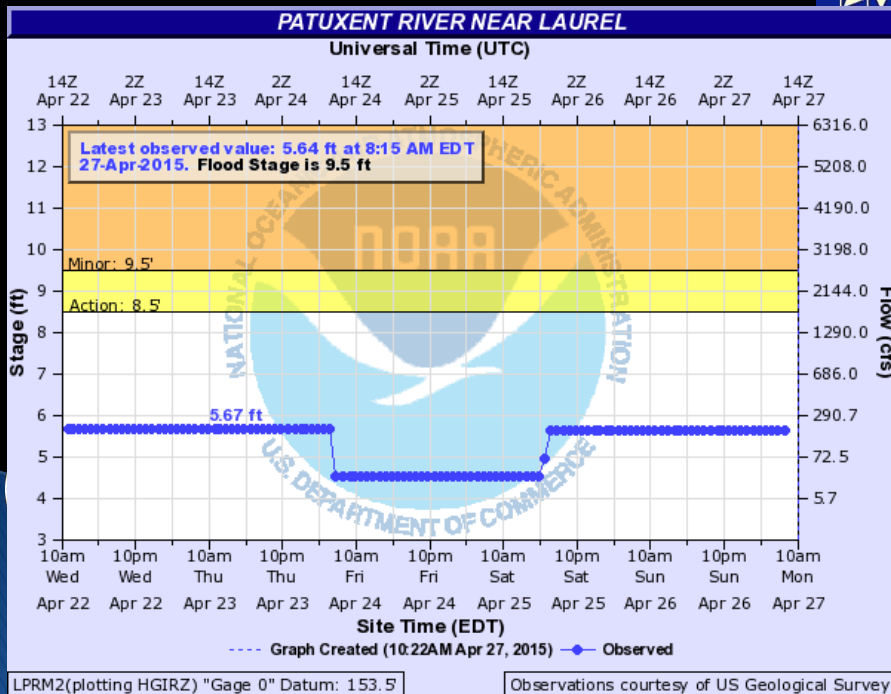


Advanced Hydrologic Prediction Service (AHPS)

<http://water.weather.gov>

Zoomed to DC metro:

<http://go.usa.gov/4vxY>



Observations during heavy rain

- ▶ Ground truth
 - Nothing ever beats an eye in the field!
 - Rainfall measurement / flood report / stream measurement
 - Safety is always key!



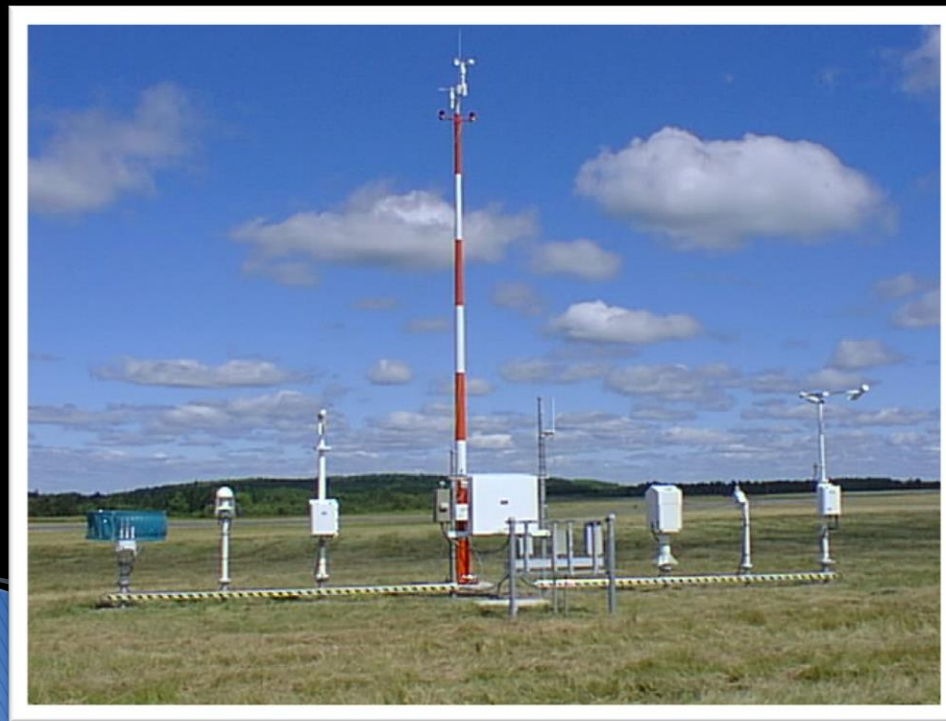
Photo courtesy Prince George's County EMS

US 301 / MD 4
Prince George's Co., MD



Observations during heavy rain

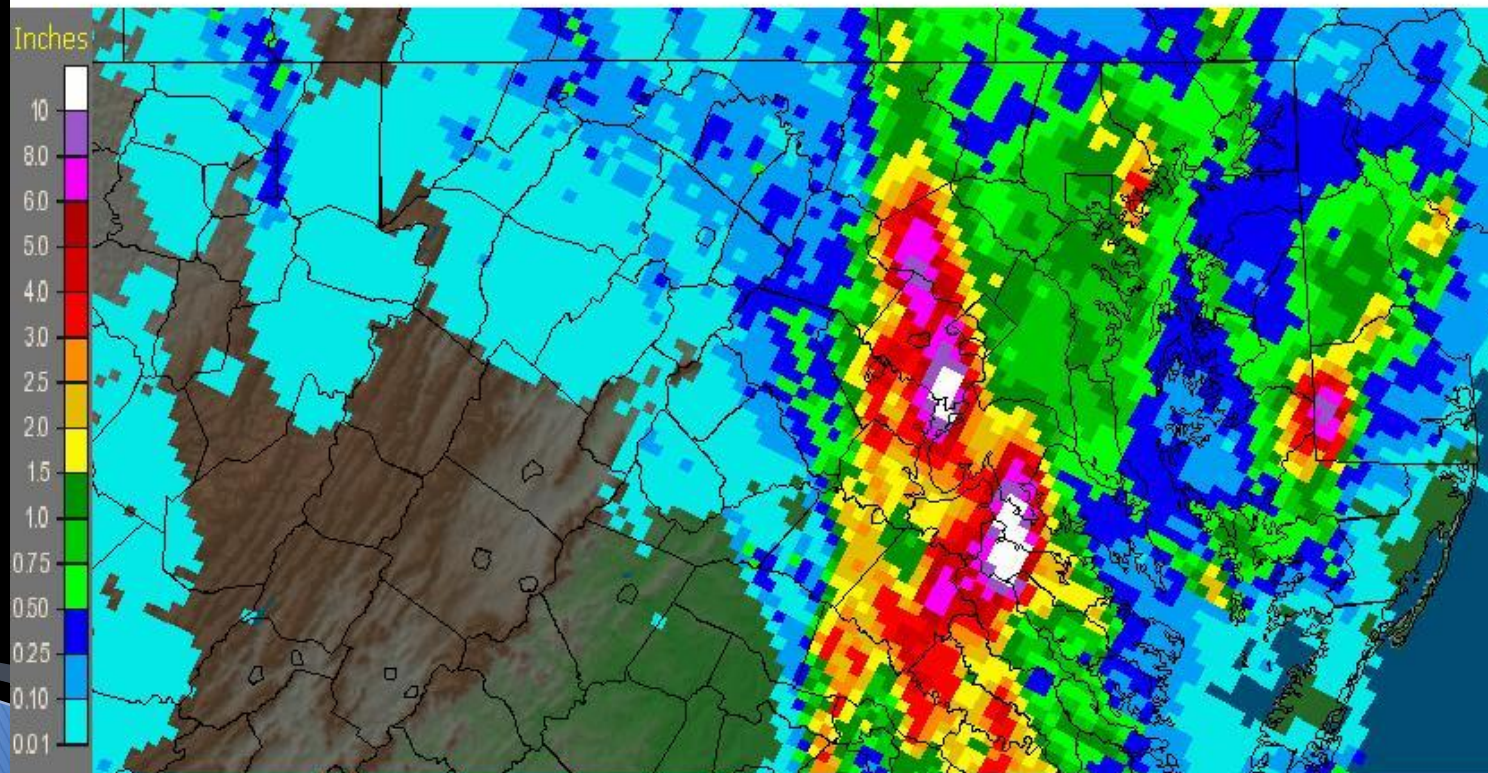
- ▶ Automated observations
 - Near-real time, but...
 - Subject to error/clogging/freezing
 - No measurement of how much of the fallen rain is being soaked into the ground, and how much is running into streams



Precipitation Estimates

- ▶ Remote Sensing
 - Radar
 - Satellite

Baltimore/Washington, VA (LWX): 9/9/2011 1-Day Observed Precipitation
Valid at 9/9/2011 1200 UTC- Created 9/11/11 23:31 UTC



The “Ultimate Combo”

- ▶ Ground truth observations
- ▶ Radar & satellite estimates skewed by ground truth
- ▶ Gaps filled in by radar & satellite
- ▶ Spotter reports are vital!
 - Rain amounts
 - River level status
 - Is there water over the road?
 - (We’ll talk more about this later...)



Ellicott City, MD

Photos by Craig Coyne

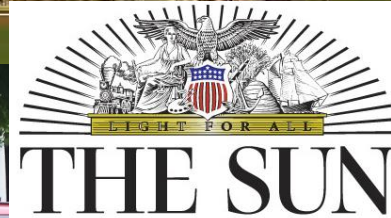


Why Do We Need Spotters?

- ▶ All one team!
 - Emergency Managers
 - Other Government Agencies
 - Broadcast and Print Media
 - SKYWARN Spotters
 - Amateur Radio Operators
 - Cooperative Observers



The Washington Post



Spotter Reports

► Answer the 4 Ws:

- Who are you?
- What is your report?
- When did this happen?
- Where did this happen?



Tips:

Give us your spotter number & name

Be descriptive about what you see

(pictures are great, but be safe!)

Be as specific about location as possible



Why Specificity Matters

- **Floods are not created equal!**



VS.

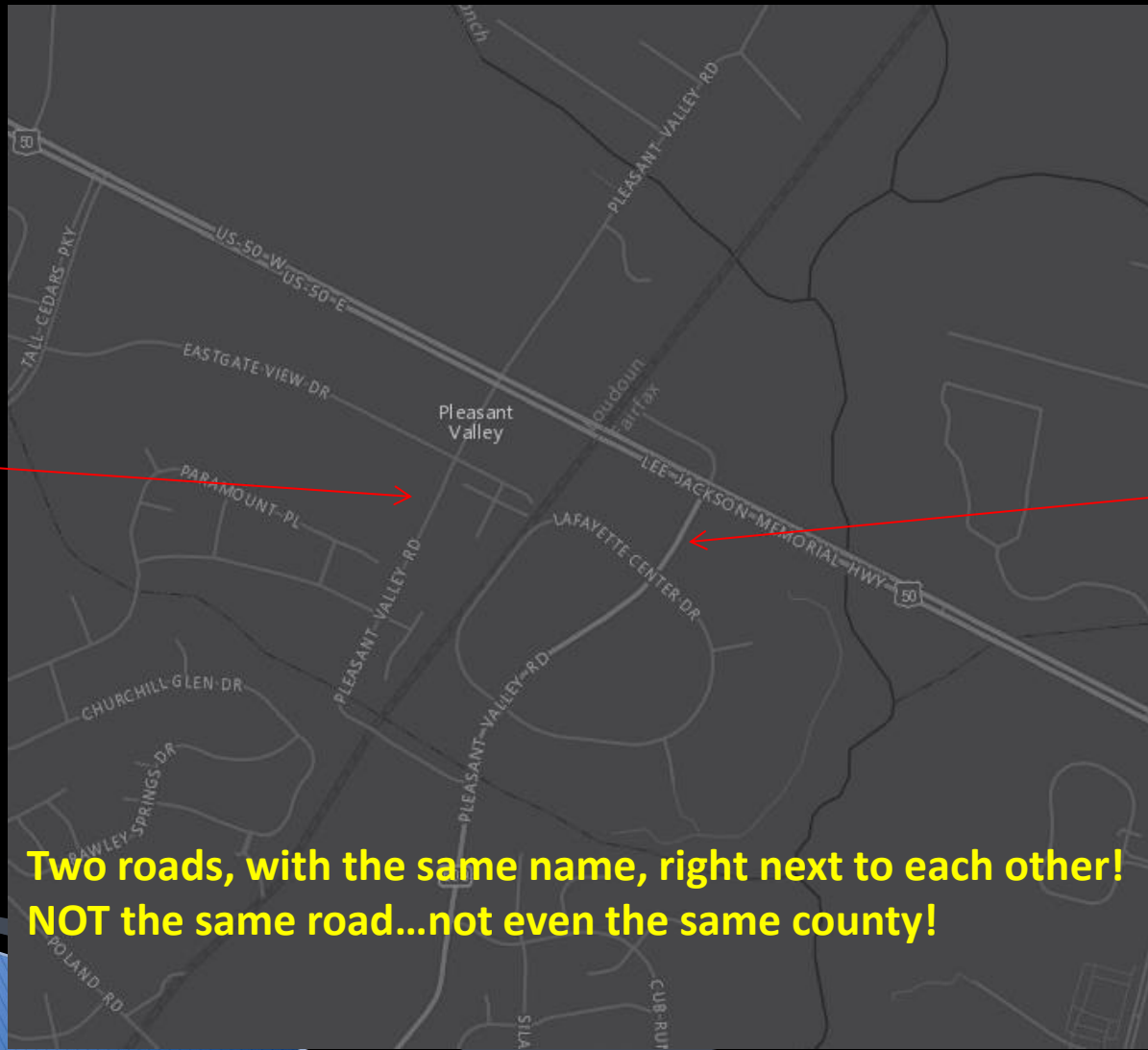


Why Specificity Matters

► Location...location...location!

**Pleasant
Valley Rd
(Loudoun Co.)**

**Pleasant
Valley Rd
(Fairfax Co.)**



**Two roads, with the same name, right next to each other!
NOT the same road...not even the same county!**



What to Report

- ▶ **Heavy Rain** – measured 1” or more (we like getting periodic reports & a storm total at end)
- ▶ **Flooding & Flash Flooding** – Streams, creeks or rivers out of banks or flooding of roads from poor drainage



Terminology:

- * Water over banks but not affecting anything – “bankfull/just over bankfull”
- * Water affecting farmland, roads, property out of floodplain – “flooding”



What to report

- ▶ **Ice Accumulation** – Any glaze on surfaces (or more)
- ▶ **Snow Accumulation** – Every 2" and a storm total, or any accumulation not reflected in the forecast



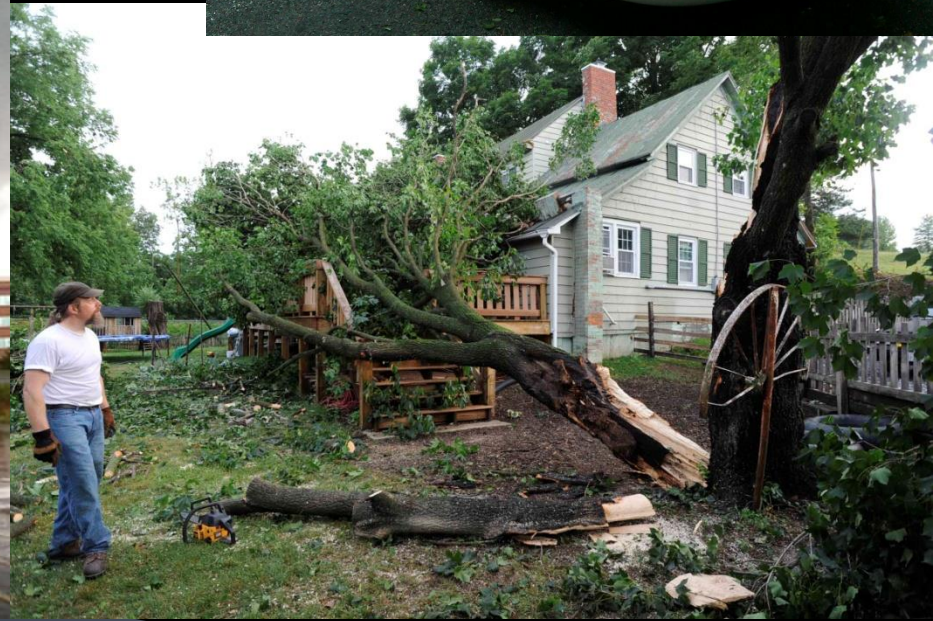
←
If half the ground has 2.0" and half the ground is bare, report 1.0" as your total depth.

→
If more than half the ground is bare report "T" (trace) and mention the range of depths in your comments.



Non-hydro spotter reports

- ▶ Although we don't go into severe reports here, if you're already a spotter by having taken our Basic course, you certainly should report that too!



How to report

- ▶ Call NWS Sterling as soon as you see something:
(800) 253-7091 or (703) 996-2200
- ▶ You can email delayed reports or pictures to:
LWX-Report@noaa.gov
- ▶ Contact local Emergency Management
- ▶ Amateur Radio (when activated)
- ▶ If you see storm damage after the event, let us know!
Immediate reports are best; but no report is too late!
- ▶ If a report is second-hand (not directly from you), please let us know that.



Best way to report

VERY IMPORTANT INFORMATION:

- ▶ Please DO NOT send flooding reports by email, unless you see it after the fact or can't get to a phone!
- ▶ This is very time critical information that needs to be relayed to forecasters immediately.
- ▶ Best means to get information to the NWS quickly is via the telephone or Amateur Radio.
- ▶ Rainfall/snowfall observations via email are fine unless you think we need to know more urgently.

PLEASE DON'T WAIT FOR US TO CALL YOU! (we will...)



Additional Reports

If you have a rain gauge or automated weather station:

- ▶ We would love to have your reports routinely!
- ▶ Rain gauge or automated weather station must be well-sited (not attached to side of house, not under trees, etc.)
- ▶ We can provide a means where you can report your information every morning via internet and it will appear in our products & analysis
- ▶ If interested, contact me directly:
jason.elliott@noaa.gov or 703-996-2234



Case Studies

- *June 1995 (Madison Co VA)*
 - *Heavy Rain/Stationary Storm*
- *January 1996*
 - *Blizzard/Thaw*
- *June 2006*
 - *Training Thunderstorms*
- *March 2010*
 - *Snowmelt, Rain, & Coastal Flooding*
- *August/September 2011*
 - *Tropical Storms*
- *January 2013*
 - *Patuxent Flood*



June 27, 1995

- ▶ Affected foothills of central Virginia
- ▶ 24" rain within 24 hours
- ▶ 3 fatalities
- ▶ Mud/Debris slides
- ▶ All bridges in and out of Madison County were washed out or damaged except for U.S. Route 29 South.



Rt. 29 @ Madison/Greene County Line



Rapidan River poured over U.S. Rt 29 at the border of Madison & Greene counties



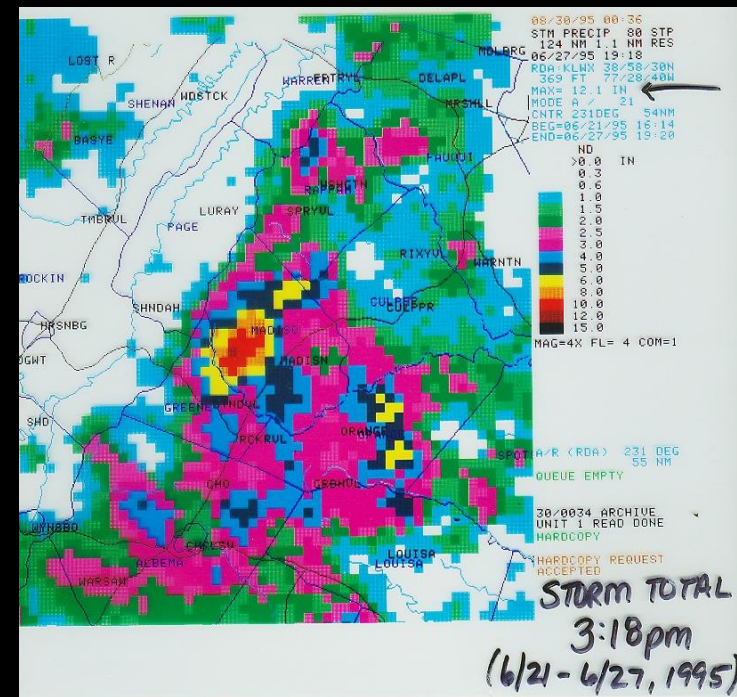
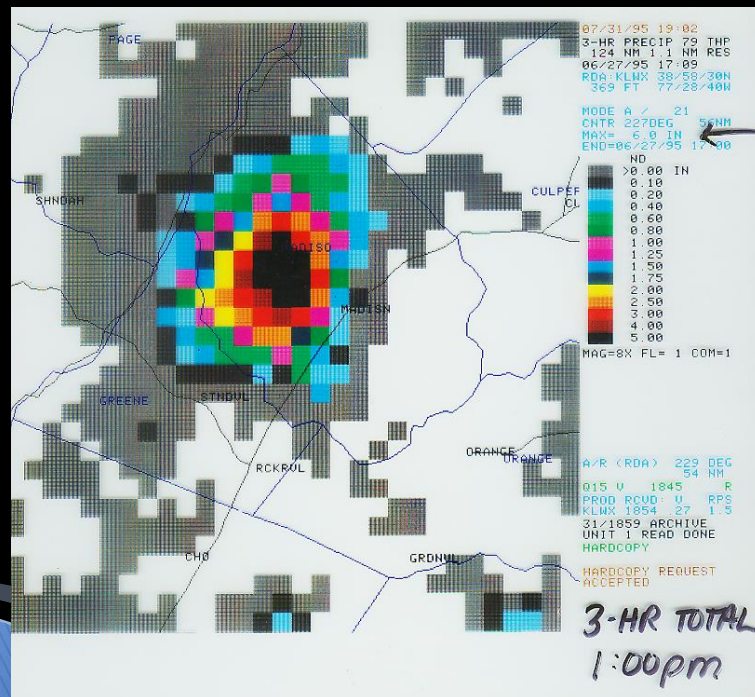
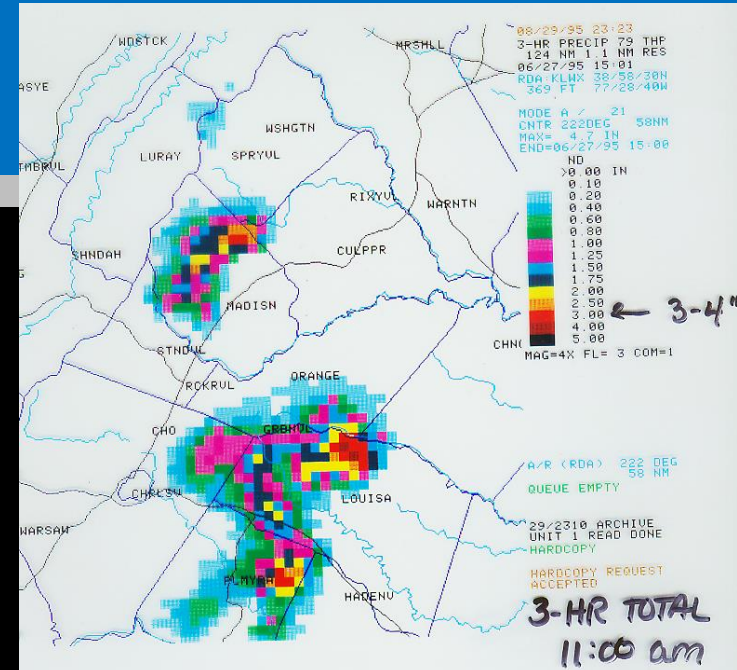
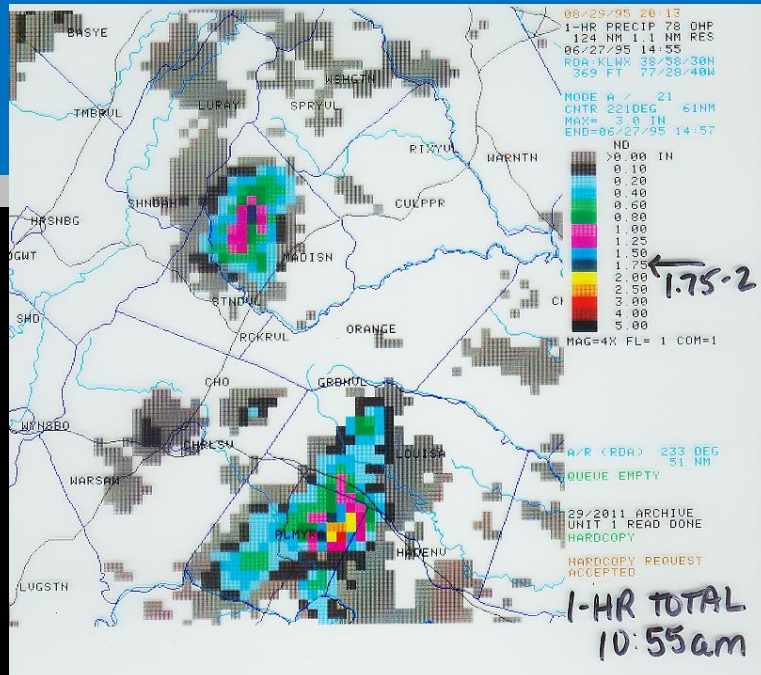
Madison County (VA) Flash Flood

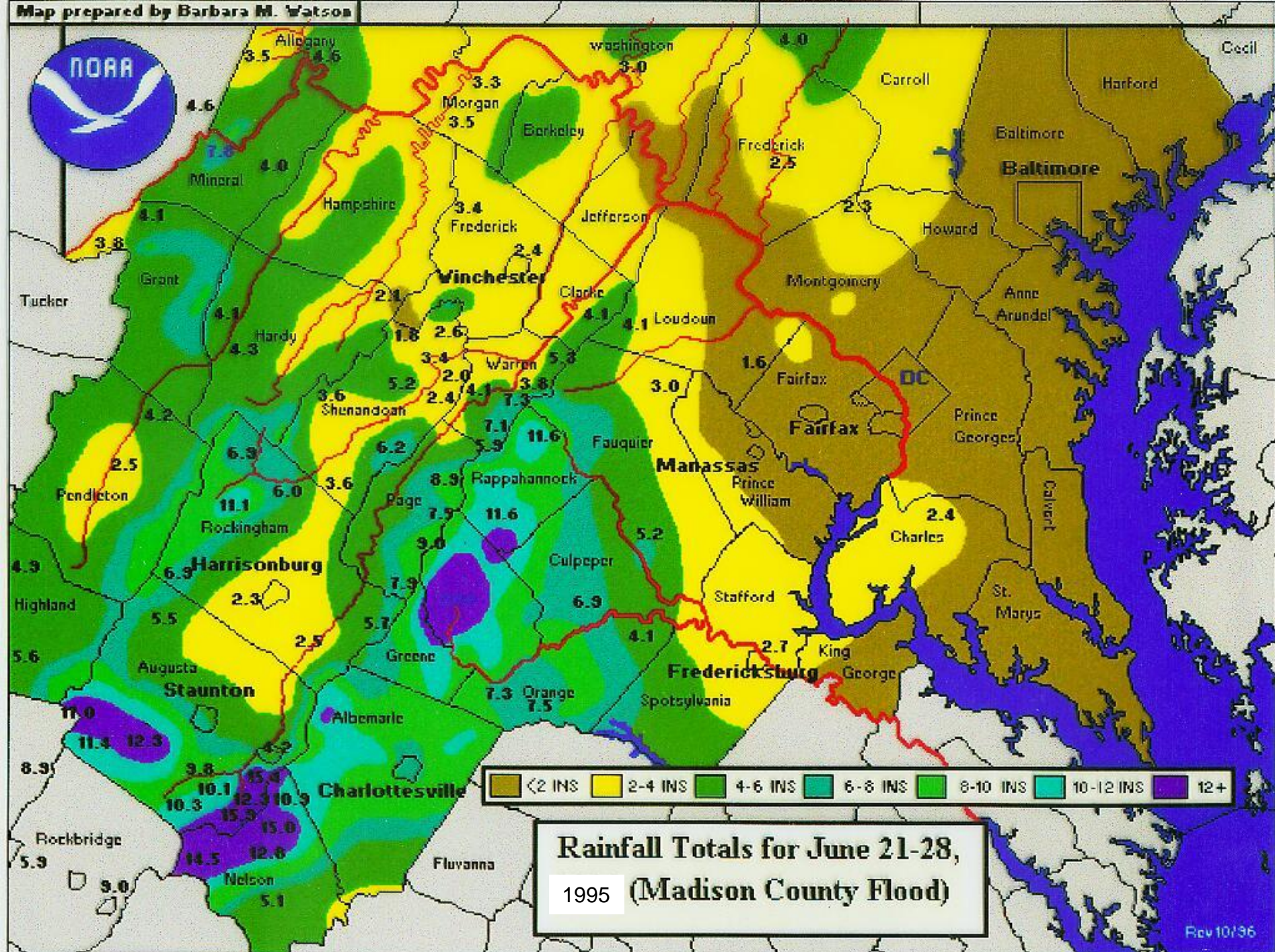
- ▶ Radar was underestimating rainfall - ratio of ground truth to radar estimates was 1.8 : 1.
- ▶ As flooding became more severe, communications were lost.
- ▶ Skywarn amateur radio spotters provided the first ground-truth report from Madison County.
- ▶ At 2PM, Etlan reported 10", with 5" falling between 10AM & 2PM.
- ▶ Record Flooding along the Rapidan River near Ruckersville and Culpeper

Debris Flow from Madison County flood

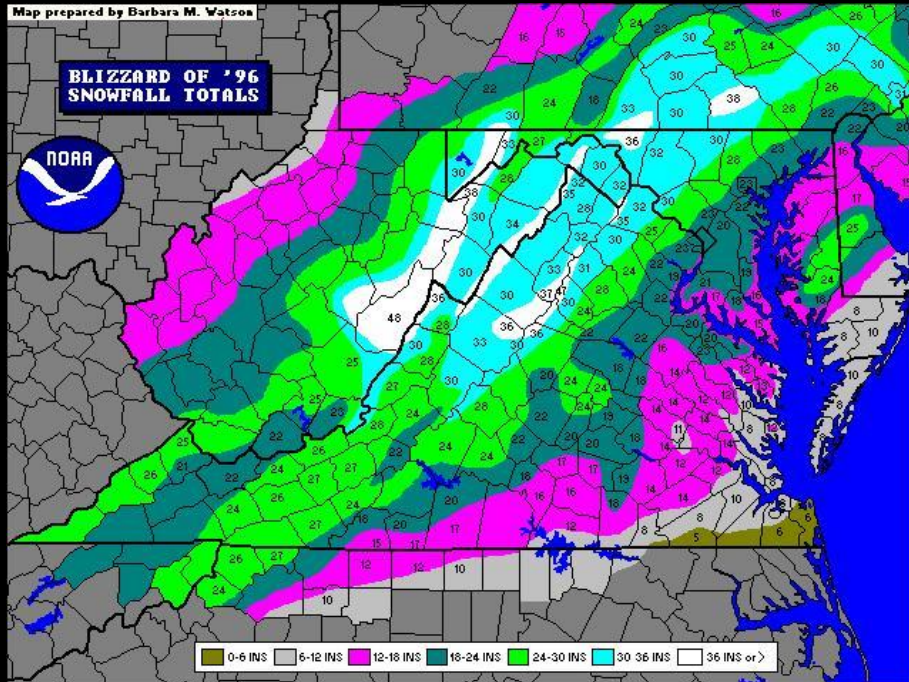


Rain



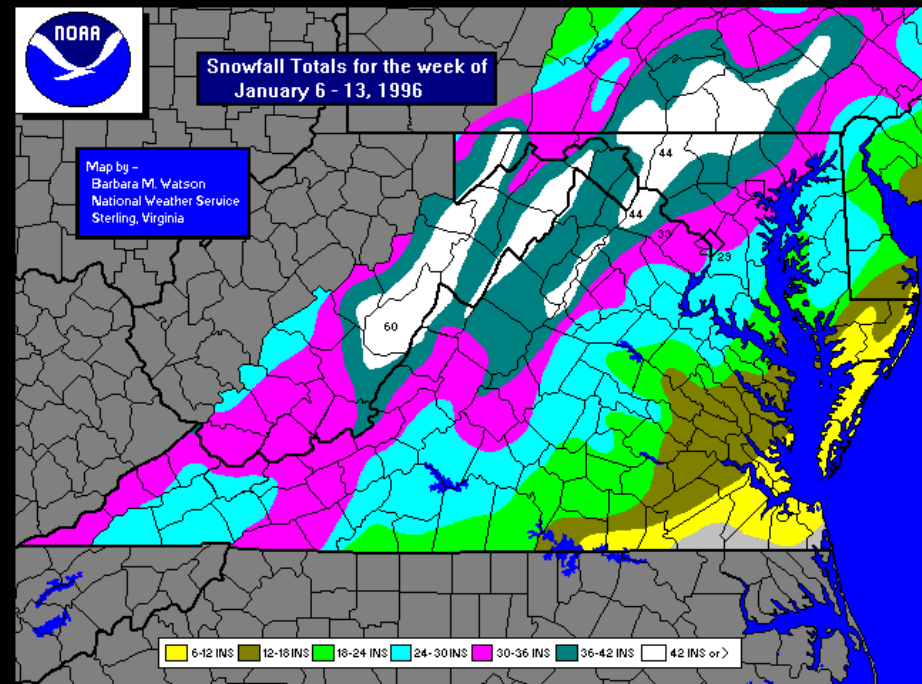


January 6-13, 1996



Snowfall from January 6-8, 1996
Blizzard

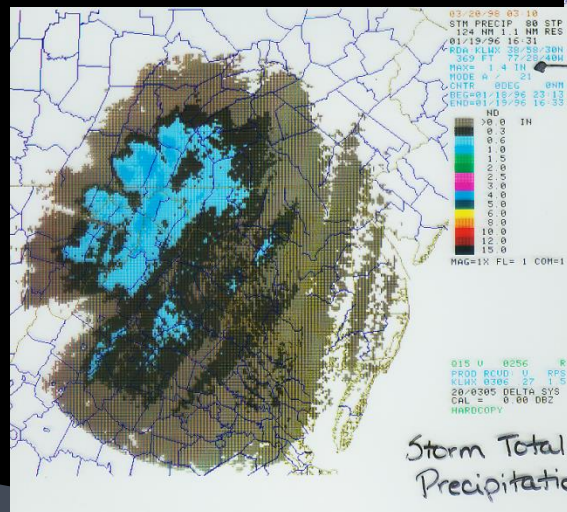
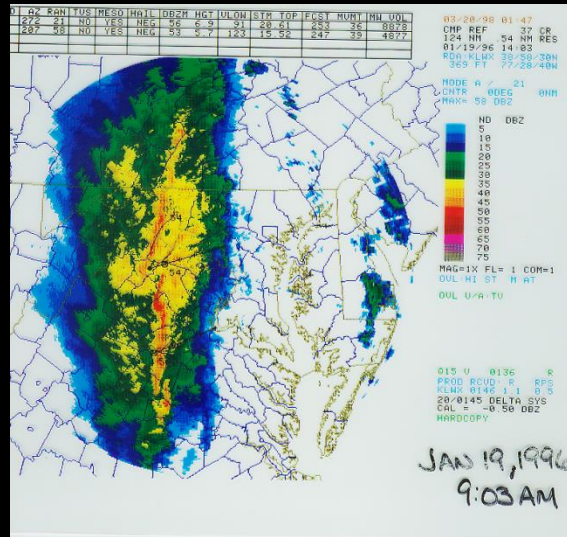
Additional snow fell January
12th. Snowfall totals for the week
January 6-13, 1996



January 19, 1996

Snowfall at Dulles Int'l Airport (IAD)

Date	New Snow	Snow on ground (7 am)
6	1.4	0
7	19.8	7
8	3.4	24
9	0.2	24
10	T	21
11	0	18
12	6.1	19
13	0	23
14	0	20
15	0	14
16	0	12
17	0	11
18	0	9
19	0	T
20	0	T
21	T	T



Radar images on Jan 19th...

-9:03 am (left)

-11:25 am (below)

Radar estimated total rainfall – max 1.4 inches



January 1996 event

- ▶ 2 – 3 feet snowfall early
- ▶ Additional snow a week later (less than 1' East & 3' West)
- ▶ Water equivalent of snow pack 2-3" (17th & 18th)
- ▶ Additional 1 – 3" rain, locally up to 5"



Above: Shenandoah Street in Harpers Ferry flooded in January 1996



Left: Flood Markers on Whites Ferry General Store include the January 1996 flood



But wait...there's more...

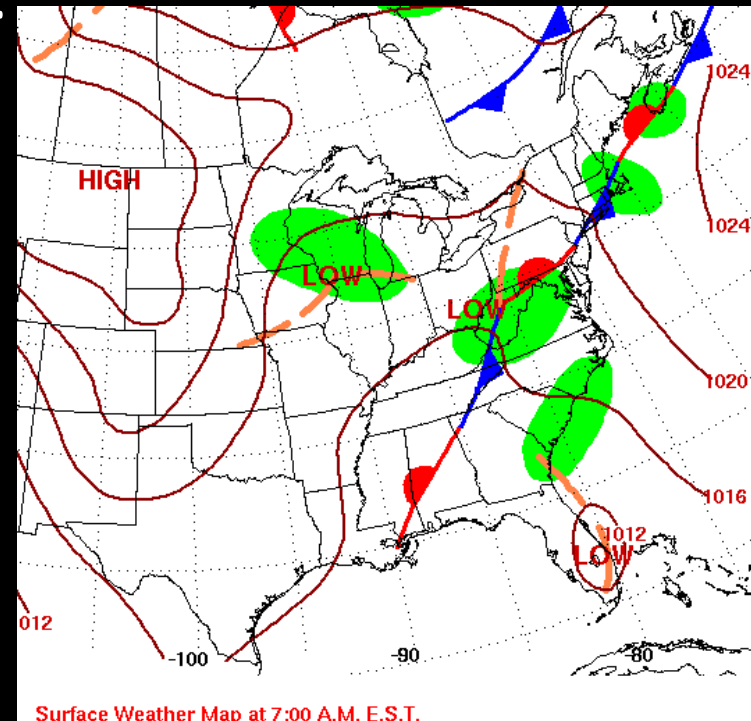
- ▶ Cleanup from the January 1996 event had just ended when Hurricane Fran slammed into the area in September, causing nearly the same flooding across the Potomac basin.
- ▶ **However...**
There hasn't been a major flood of the Potomac since.
(There have been lots of minor & moderate floods)

Are we overdue?



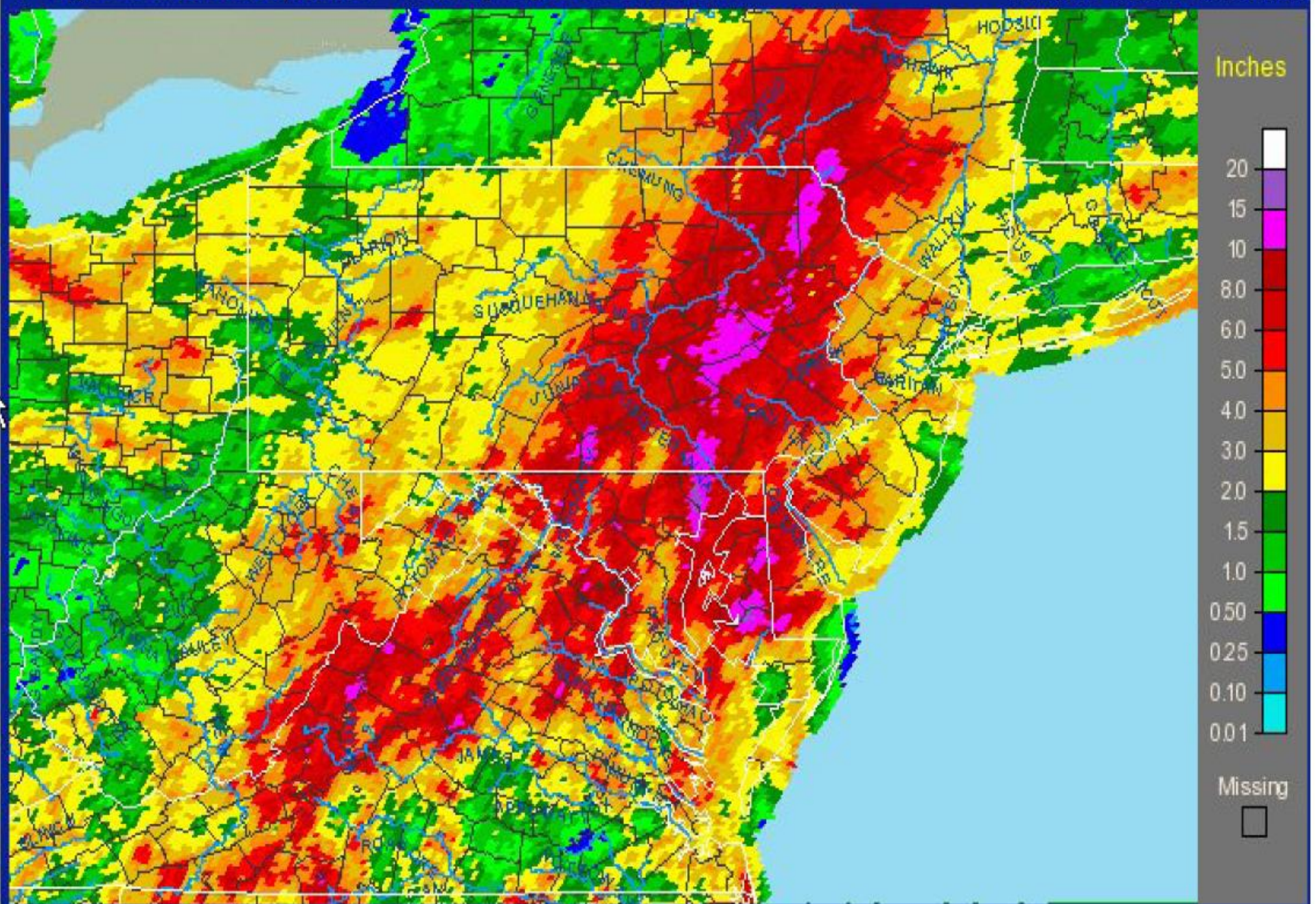
June 2006 Heavy Rain Event

- ▶ Waves of low pressure rode northeast along a stationary front from June 22 until June 27.
- ▶ Flow in the atmosphere was parallel to the boundary, producing several rounds of training echoes.
- ▶ As a result, double digit rainfall totals affected parts of the region through the five days.
- ▶ Scattered instances of flash flooding began late on June 22 and continued into June 24. Then, flooding began to take on a more serious nature since the ground had become saturated in so many spots.



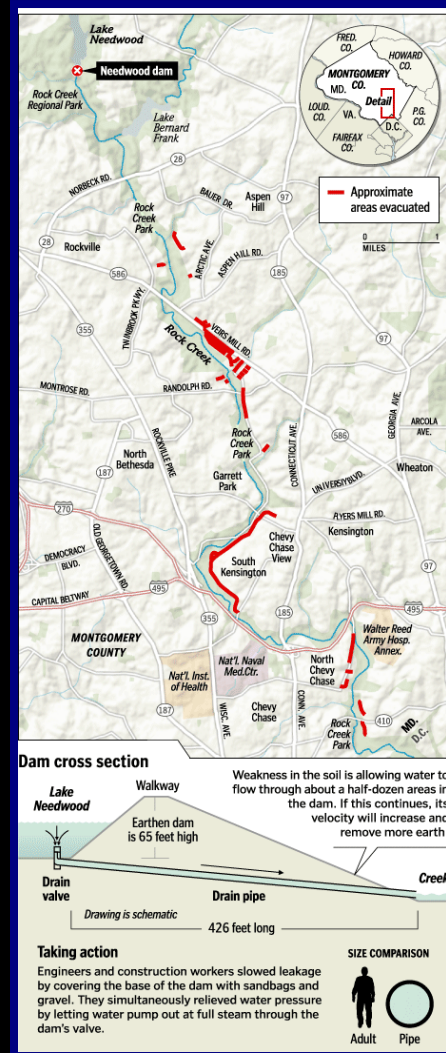
Middle Atlantic RFC State College, PA
7-Day Observed Precipitation - Valid 6/28/2006 1200 UTC

Click on the image to zoom in
Click on "States" to zoom out



2006 Impacts – Lake Needwood

- ▶ Nearly 2400 people in Montgomery County, MD were evacuated when engineers on site determined that the Lake Needwood Dam may fail.
- ▶ Water levels behind the dam rose 23 feet, resulting in uncontrolled seepage.



2006 Impacts – Rock Creek

- ▶ 5 deaths in Frederick (MD) & Carroll Counties
- ▶ In Huntington VA, 158 homes were declared uninhabitable, two homes and one business were condemned. (\$11M)
- ▶ Flooding and mudslides closed portions of Capital Beltway
- ▶ Rock Creek flooded, and threw several vehicles up against trees due to the fast flowing high water.



Flood damage along Rock Creek.

A record setting day!

► At Reagan National Airport (DCA)...

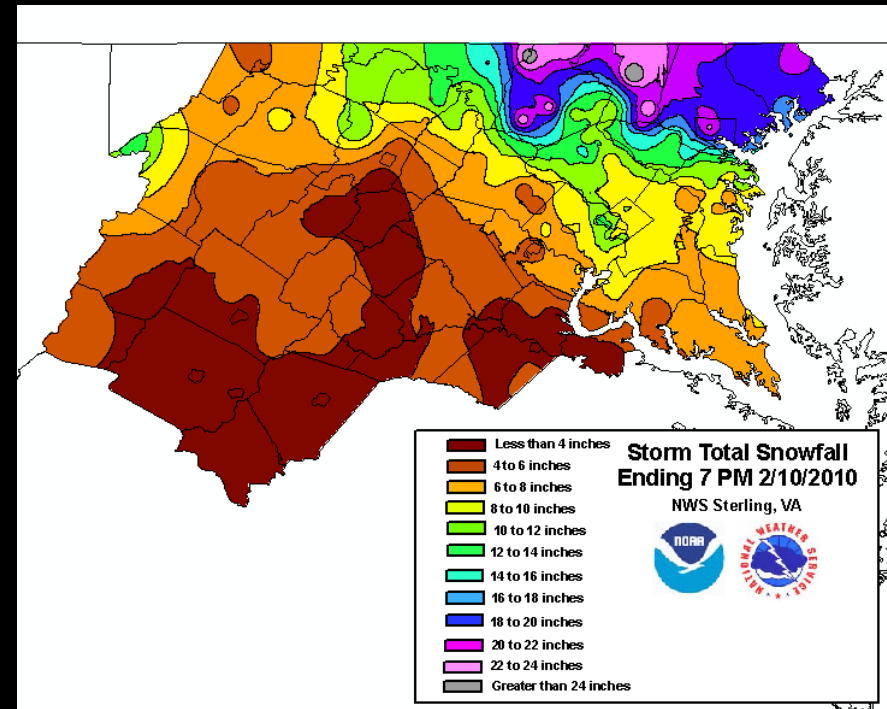
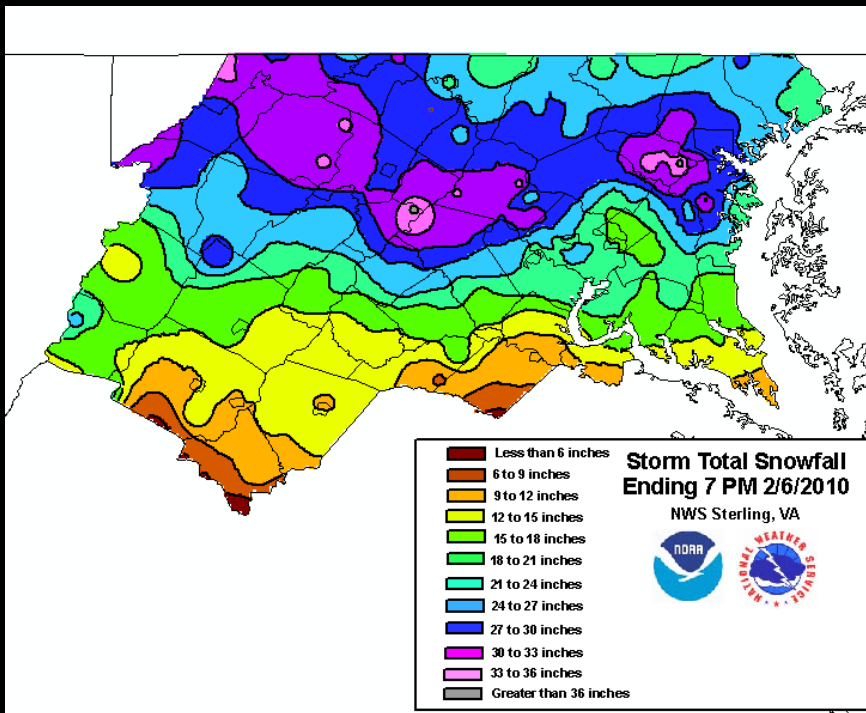
24-hour rainfall record...	7.94" (6/25-26)
Daily rainfall record...	5.19" (6/25)
Daily rainfall record...	4.22" (6/26)
2-day rainfall record...	9.41" (6/25-26)
7-day rainfall record...	11.37" (6/22-28)
June rainfall record...	14.02"



March 2010

- ▶ Believe it or not, this event really began a month before:

Two rounds of heavy snow: February 5-6, and again 9-10



A slow melt...

- ▶ Next 30 days had below normal temperatures
- ▶ Max temperatures above freezing allowed for controlled melting
- ▶ Min temperatures below freezing at first, then gradually above freezing
- ▶ By early March, snowpack only in the mountains
- ▶ Rain March 12-15th

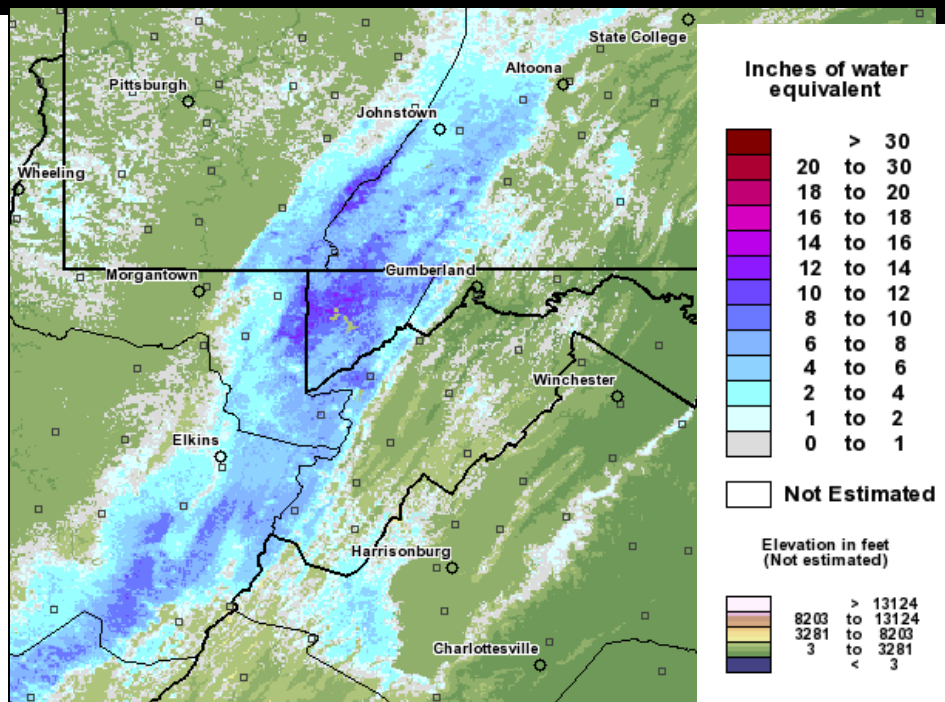
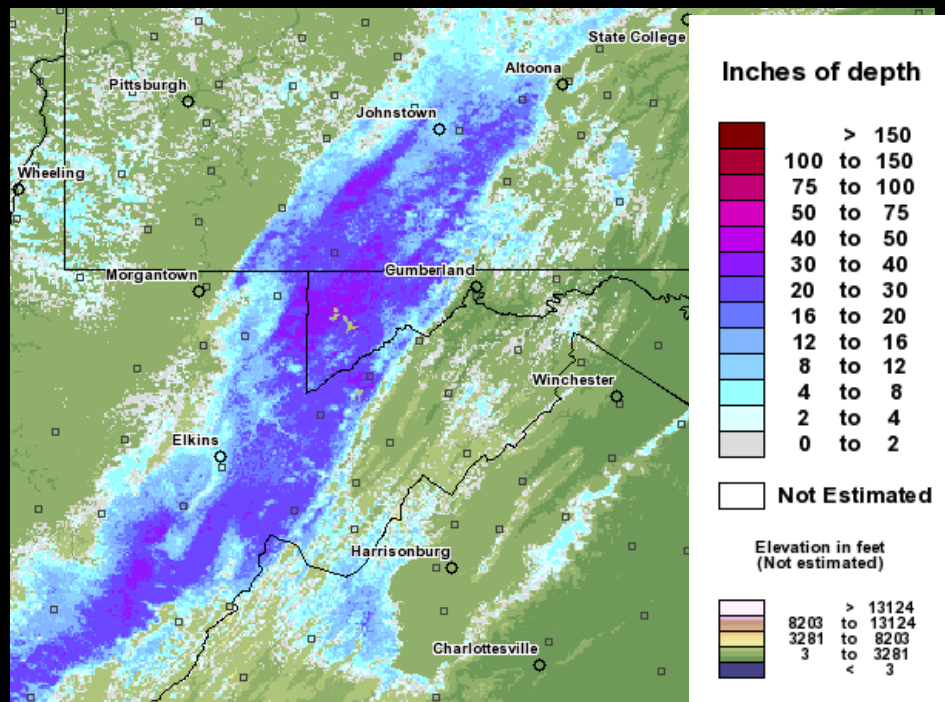
Feb 2010 data – National Airport				
Date	Liquid pcpn	Snowfall	Snow on Ground	High temp.
5	0.77	8.7	0	37
6	0.73	9.1	13	32
7	0	0	18	32
8	0	0	14	34
9	0.38	3.7	13	36
10	0.25	7.1	14	31
11	0	0	21	40
12	0	0	17	38
13	0	0	15	34
14	0	0	14	41
15	0.04	0.1	13	39
16	T	T	12	37
17	0	0	10	37
18	0	0	9	43
19	0	0	7	45
20	0	0	6	44
21	0	0	4	50
22	0.27	0	1	43



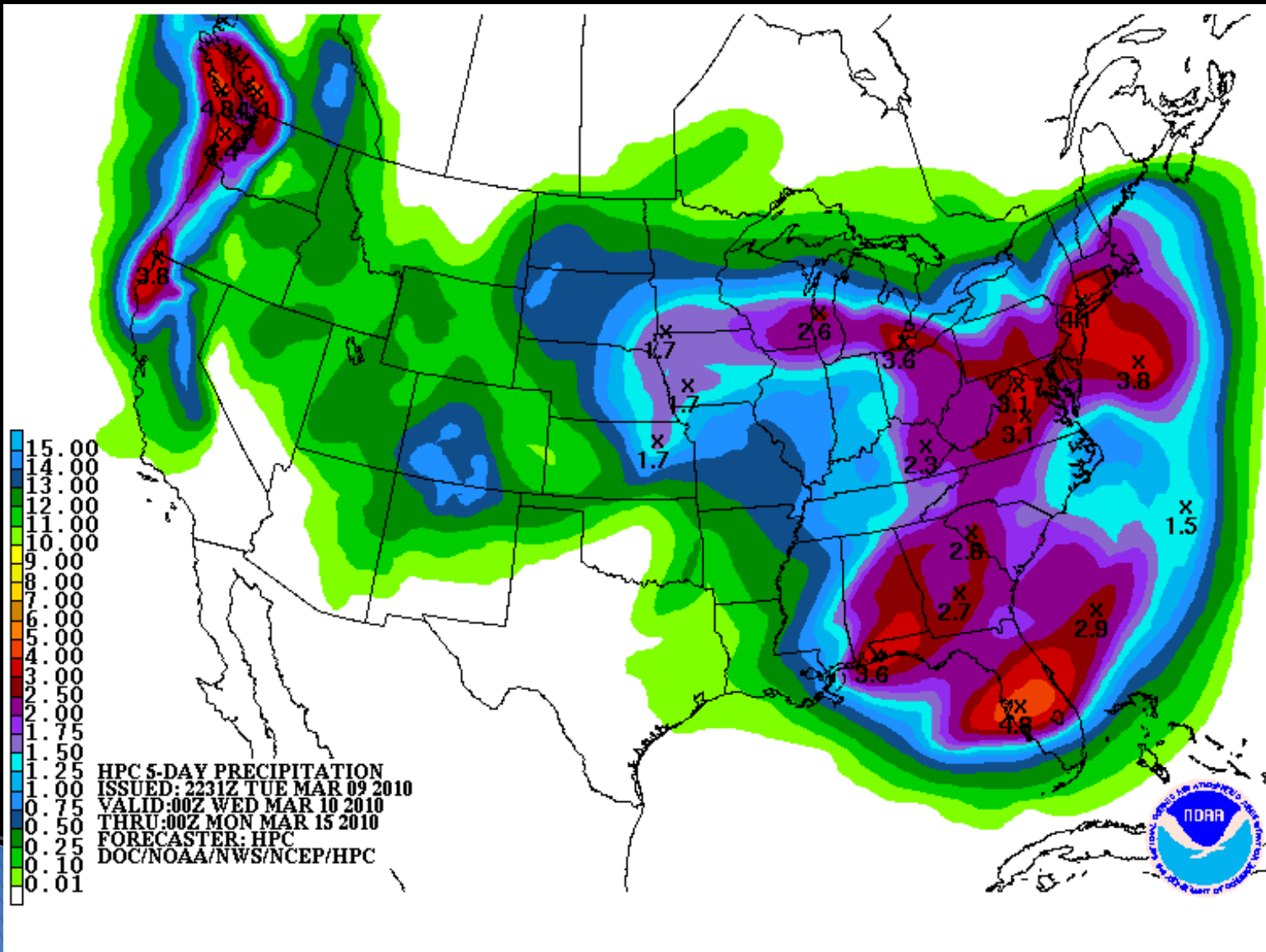
What remains...

March 11th Snow Depth

March 11th Snow Equivalent

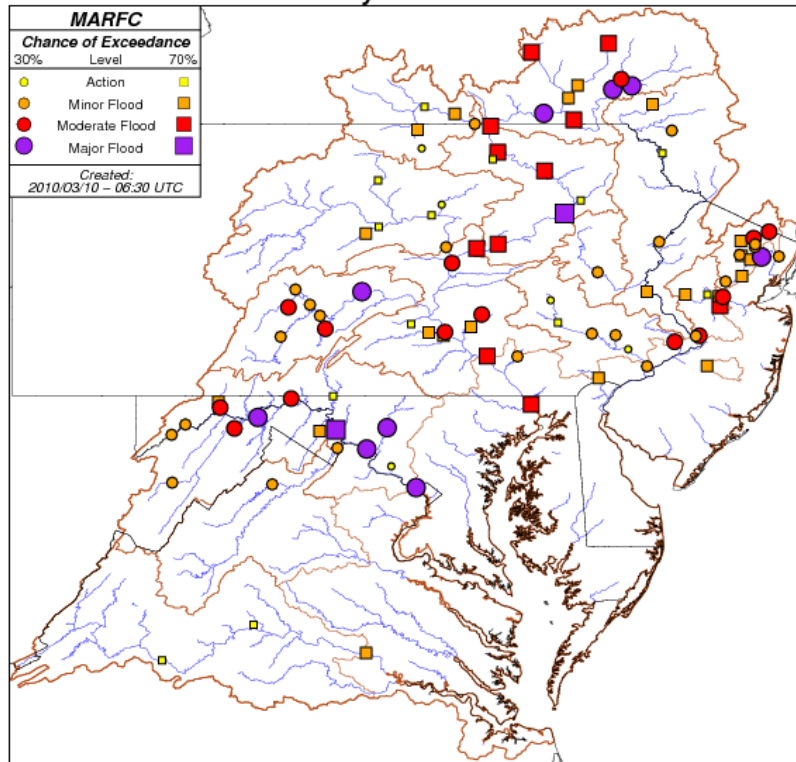


This could be trouble...

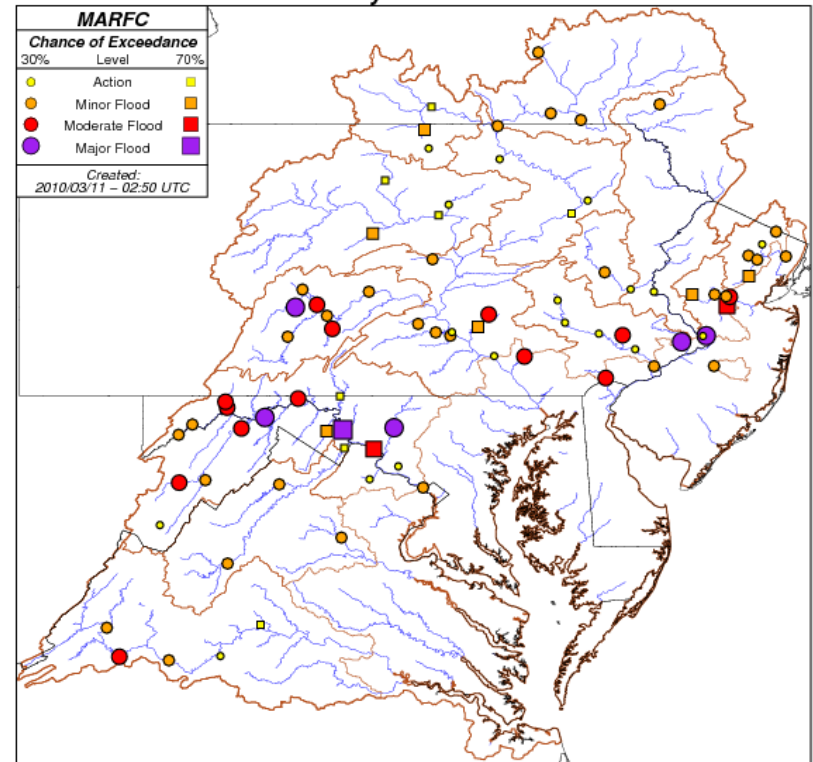


Ensemble Forecasts

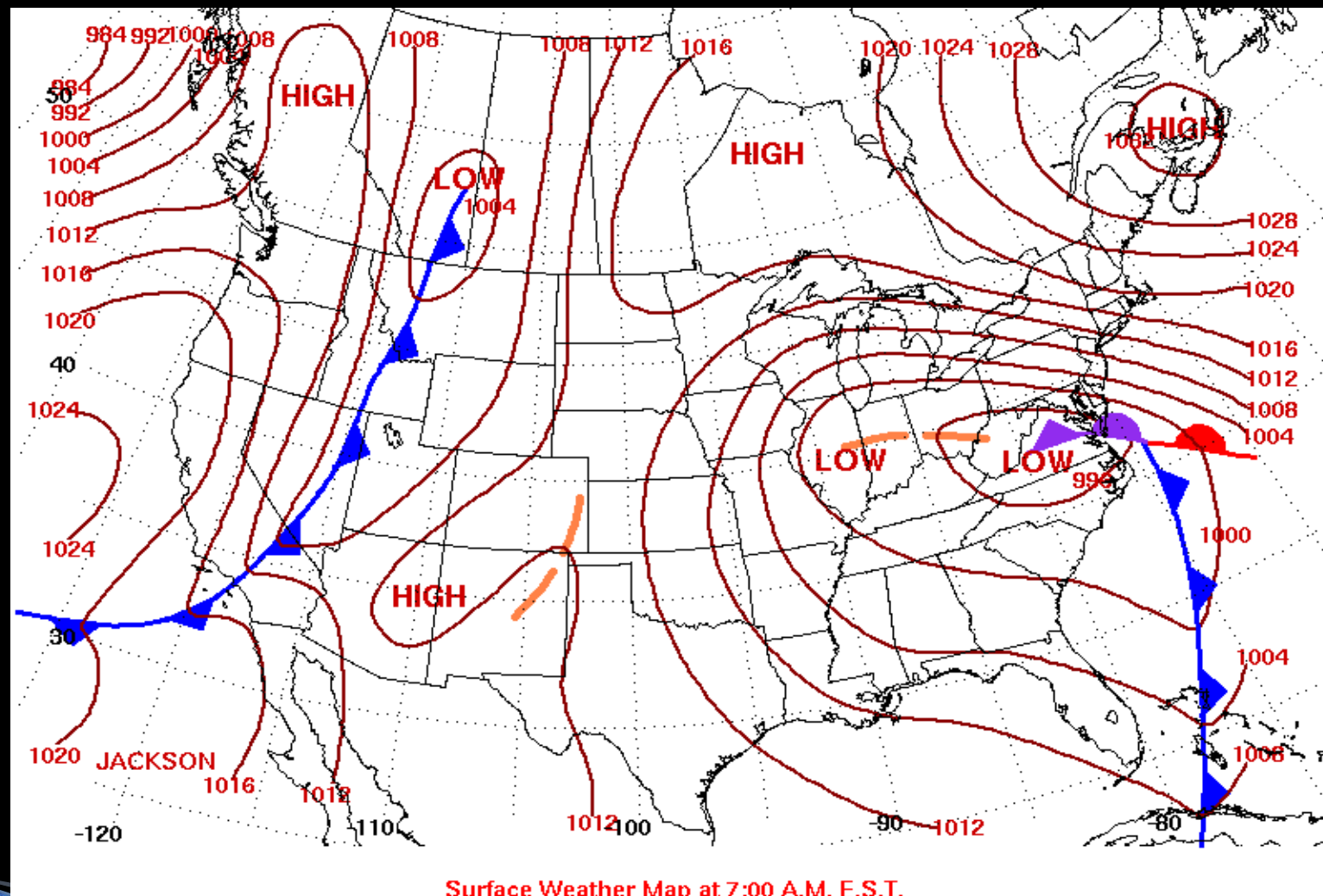
GEFSA Ensemble Summary for 3/9/2010 – 3/16/2010
Forecast Cycle: 2010/03/10/00



SREF Ensemble Summary for 3/10/2010 – 3/13/2010
Forecast Cycle: 2010/03/10/21



Coastal Flood Concern



Ground Truth

WASHINGTON, DC

WASHINGTON 4.0 WNW	5.65
--------------------	------

MARYLAND

ELKRIDGE 1.8 W	4.79
----------------	------

THURMONT 0.8 SSE	3.96
------------------	------

SEVERN 2.0 W	3.93
--------------	------

SMITHSBURG 3.1 NNE	3.88
--------------------	------

PERRY HALL 0.9 E	3.85
------------------	------

TOWSON 2.3 NE	3.83
---------------	------

SOUTH GATE 1.0 SW	3.81
-------------------	------

FREDERICK 3.1 NW	3.77
------------------	------

BWI AIRPORT	3.77
-------------	------

CROFTON 1.5 NNE	3.56
-----------------	------

VIRGINIA

WASHINGTON 3.2 W	4.36
------------------	------

WINCHESTER 9.4 NW	3.98
-------------------	------

LEESBURG 8.0 N	3.85
----------------	------

RIXEYVILLE 6.1 N	3.57
------------------	------

STEPHENS CITY 2.2 E	3.57
---------------------	------

ROUND HILL 2.7 WSW	3.42
--------------------	------

WARRENTON 3.5 SE	3.28
------------------	------

VIRGINIA (CONTINUED)

STRASBURG 3.7 N	3.11
-----------------	------

BARBOURSVILLE 1.1 NW	2.94
----------------------	------

REMINGTON 4.0 ENE	2.71
-------------------	------

LAKE RIDGE 1.7 SW	2.62
-------------------	------

STAFFORD 2.0 NNW	2.59
------------------	------

STANARDSVILLE 2.1 WNW	2.59
-----------------------	------

FREDERICKSBURG 5.2 SSW	2.39
------------------------	------

ALEXANDRIA 1.8 S	2.00
------------------	------

NATIONAL AIRPORT	1.57
------------------	------

DULLES AIRPORT	1.37
----------------	------

WEST VIRGINIA

BUNKER HILL 0.8 WNW	4.21
---------------------	------

CHARLES TOWN 2.5 NE	2.60
---------------------	------

FALLING WATERS 2.4 NW	2.49
-----------------------	------

SHENANDOAH JUNCTION	2.44
---------------------	------

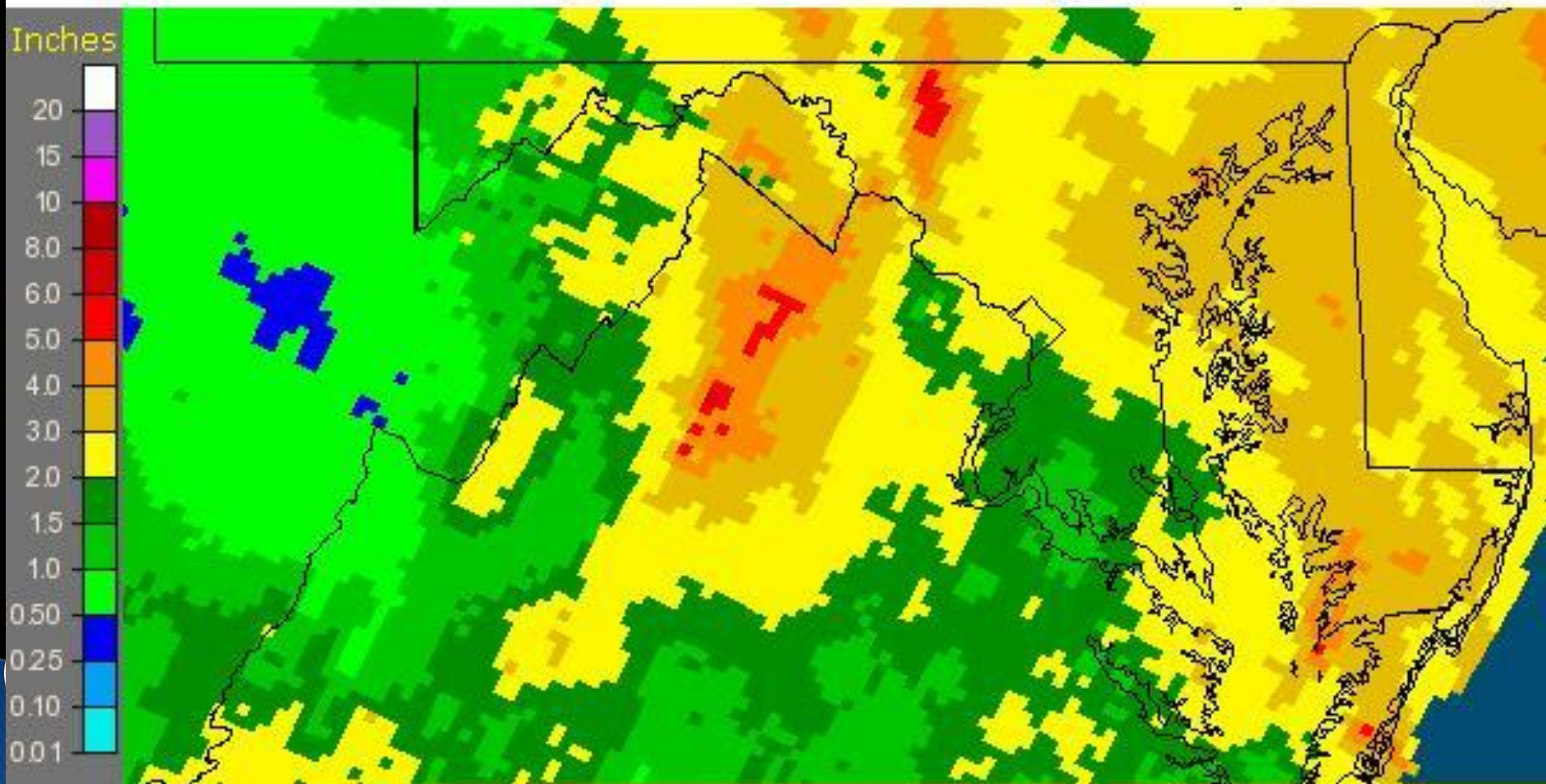
MARTINSBURG 8.0 ENE	2.34
---------------------	------



Estimated Rainfall

Baltimore/Washington, VA (LWX): Current 7-Day Observed
Precipitation

Valid at 3/15/2010 1200 UTC- Created 3/15/10 23:02 UTC

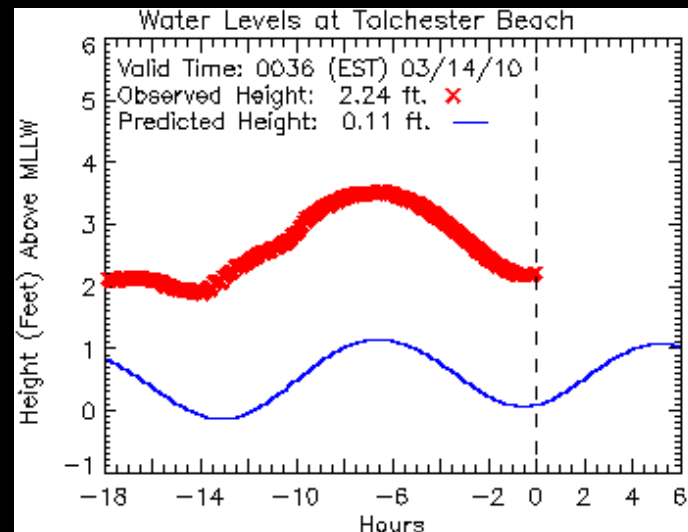
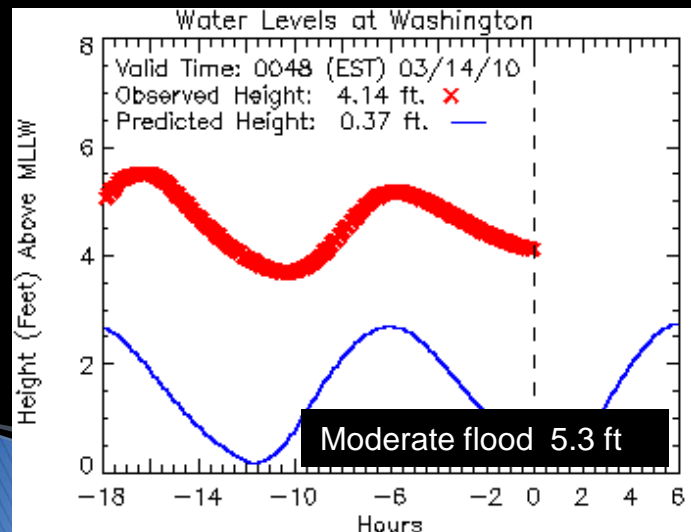
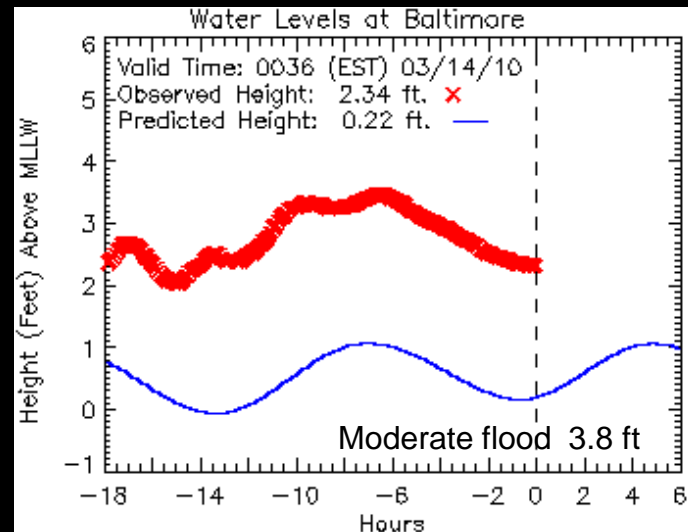
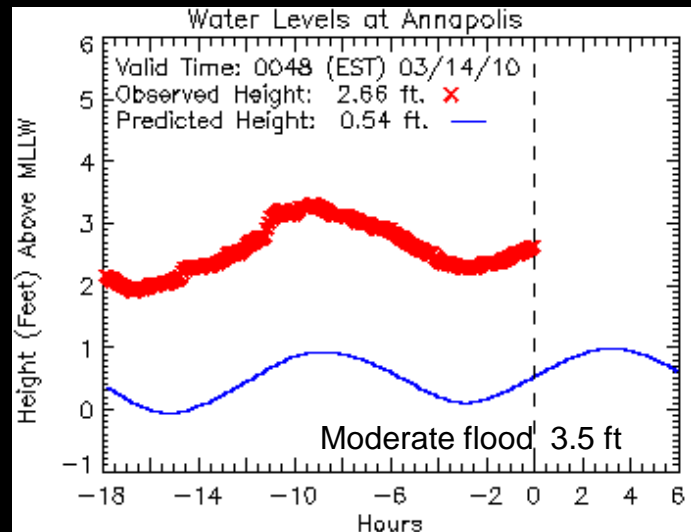


Areal Flooding

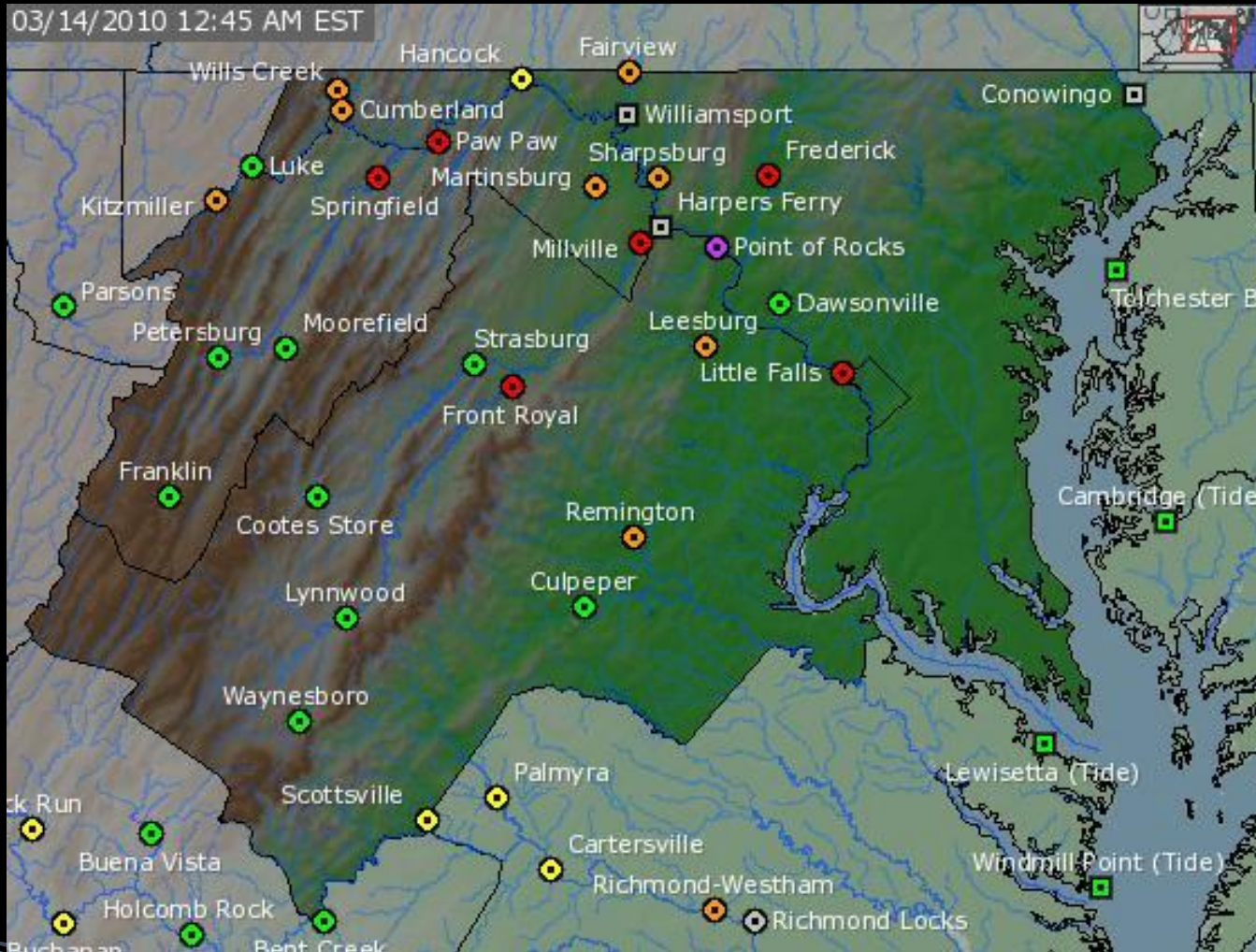
- ▶ Numerous reports of urban and stream flooding, mainly on March 13. The flooding was concentrated in Shenandoah Valley/northern foothills of Virginia, and in metro Baltimore areas.
- ▶ Additional flooding was reported the morning of the 14th, as another band of rain crossed the area.



Tidal Flooding



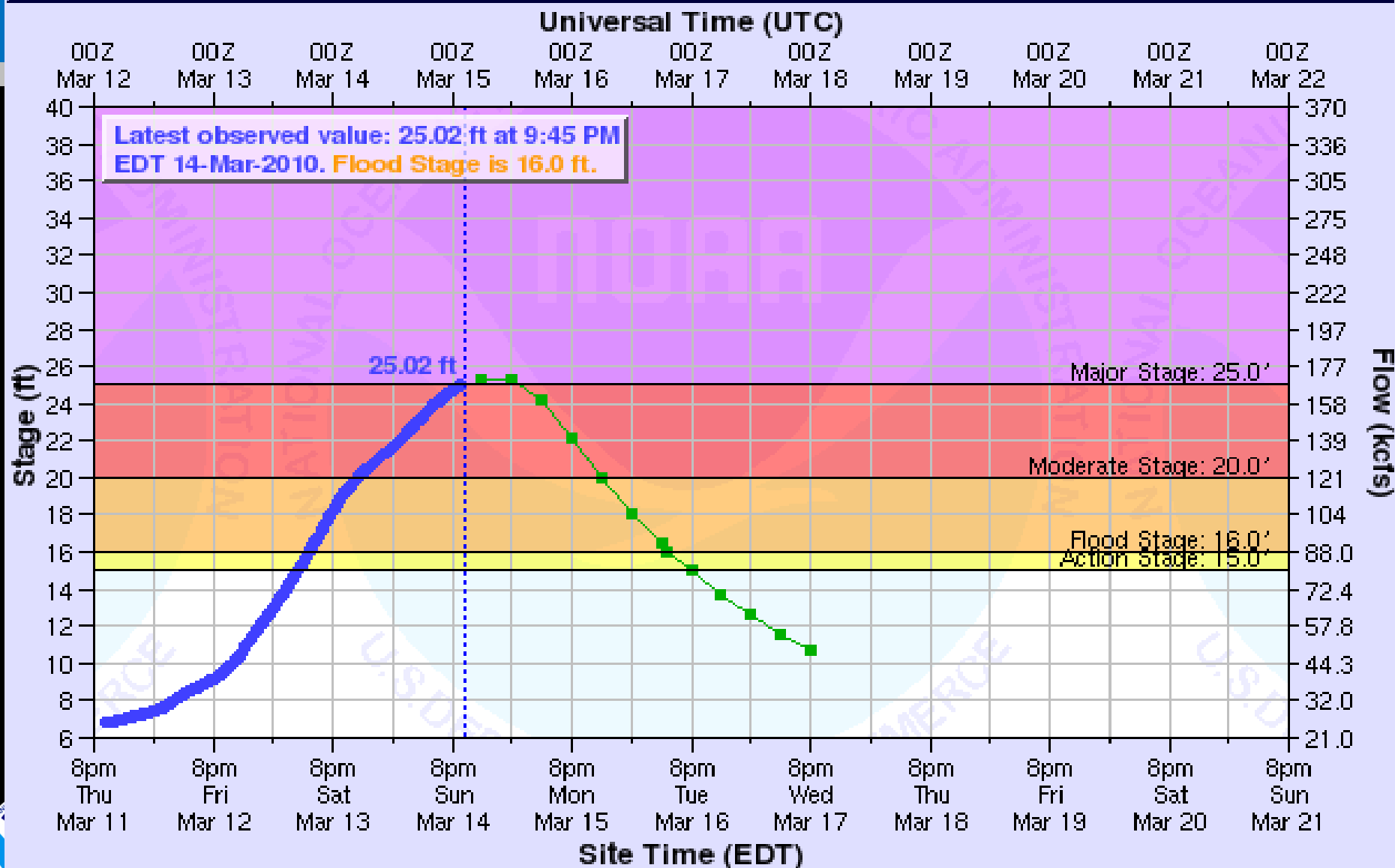
River Flooding



Minor
Moderate
Major



POTOMAC RIVER 1 WSW POINT OF ROCKS



..... Graph Created (10:37pm Mar 14, 2010) ● Observed ■ Forecast (issued 8:11pm Mar 14)

PORM2 (plotting HGIRG) "Gage 0" Datum: 200.63'

Observations courtesy of the US Geological Survey

Millville, Martinsburg, Frederick



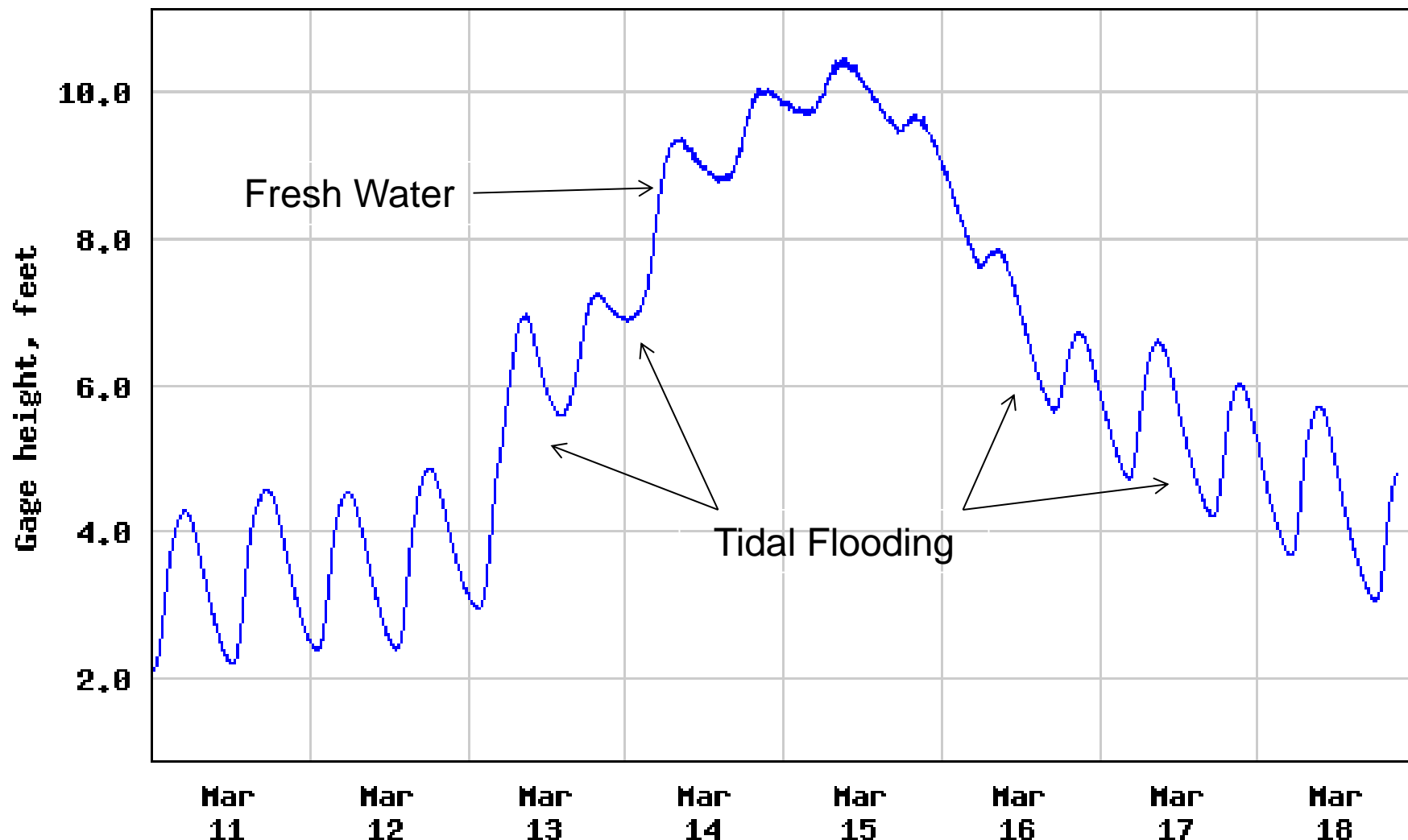
03/14/2010

03/14/2010

03/14/2010

03/14/2010 14:35:00
03/14/2010 14:35:00

USGS 01647600 POTOMAC RIVER AT WISCONSIN AVE, WASHINGTON, DC



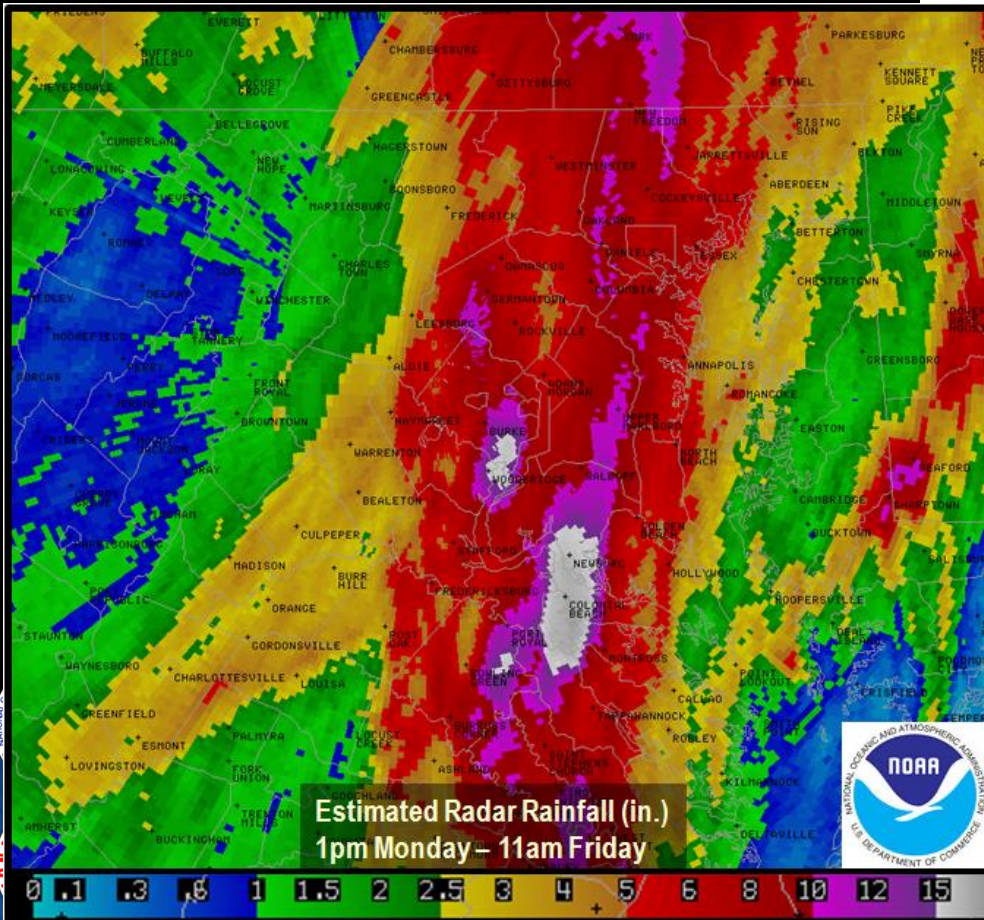
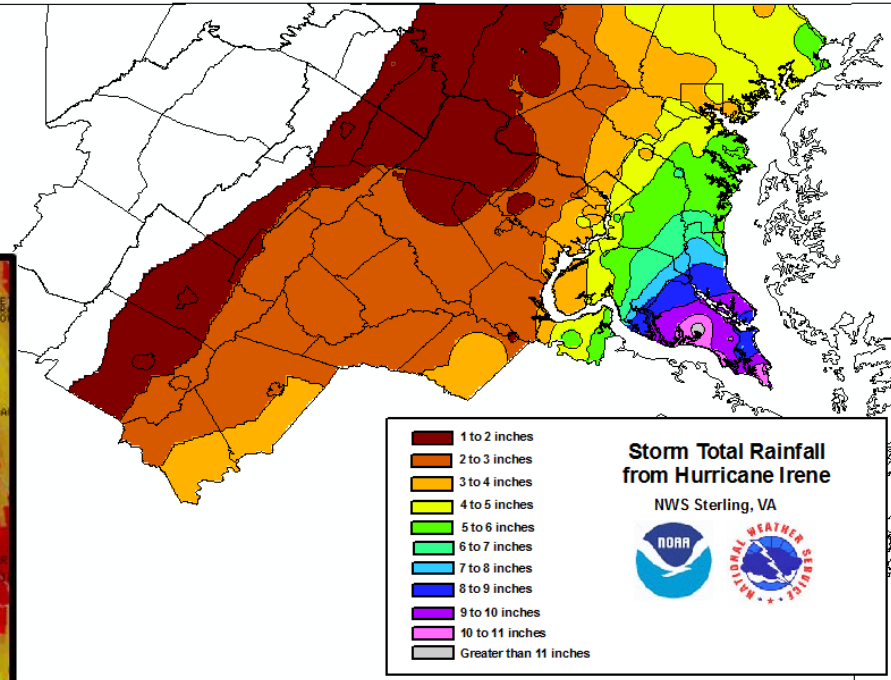
----- Provisional Data Subject to Revision -----

Alexandria & Washington DC



2011 Tropical Systems

- ▶ Right: Irene
- Below: Lee



Lee Time Lapse



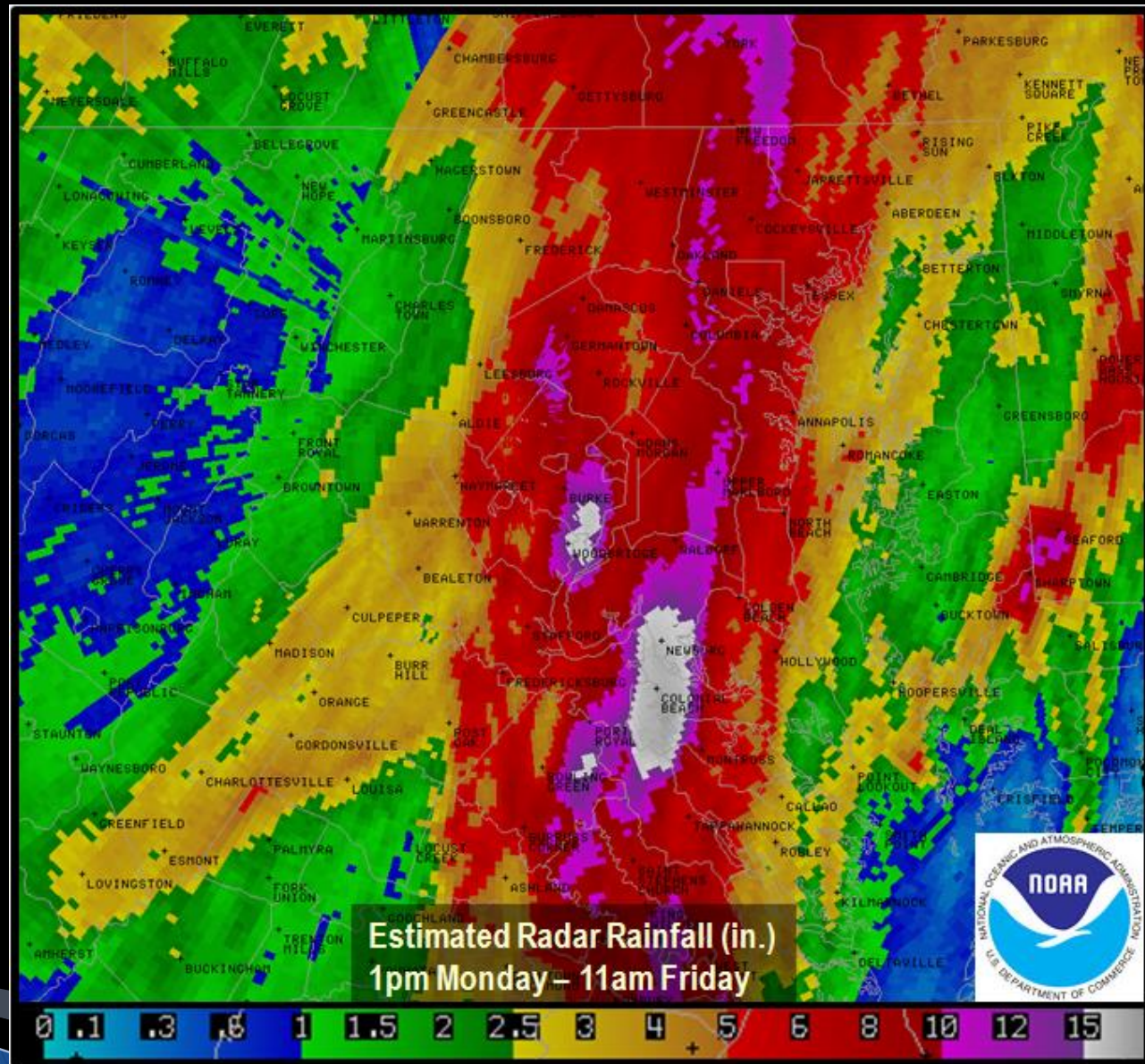
Time lapse photography of the peak
flooding associated with Tropical Storm
Lee
Sept. 8 2011

Difficult Run, near Vienna, VA
USGS streamgage 1645704
and
Difficult Run, near Reston, VA
Downstream of W+OD Trail

For more information:
Ed Schenk
eschenk@usgs.gov
profile.usgs.gov/eschenk

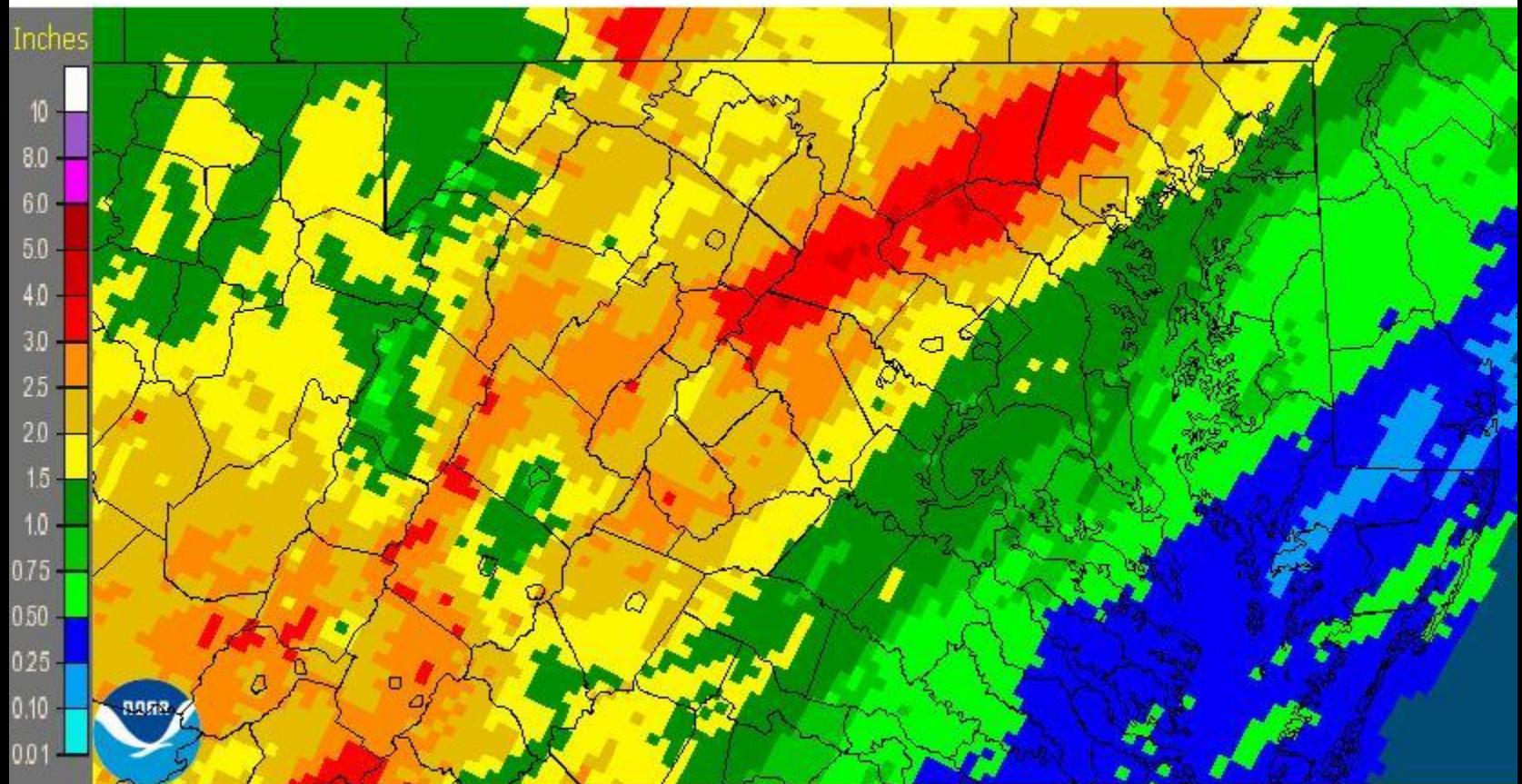


What if...



2013 Patuxent Flood

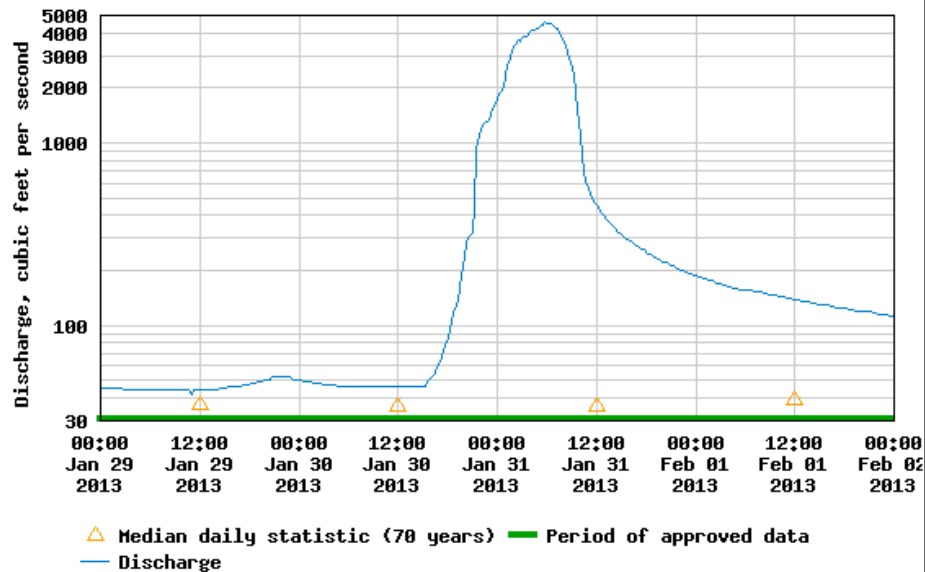
Baltimore/Washington, VA (LWX): 1/31/2013 1-Day Observed Precipitation
Valid at 1/31/2013 1200 UTC- Created 6/18/14 4:49 UTC



2013 Patuxent Flood



USGS 01591000 PATUXENT RIVER NEAR UNITY, MD



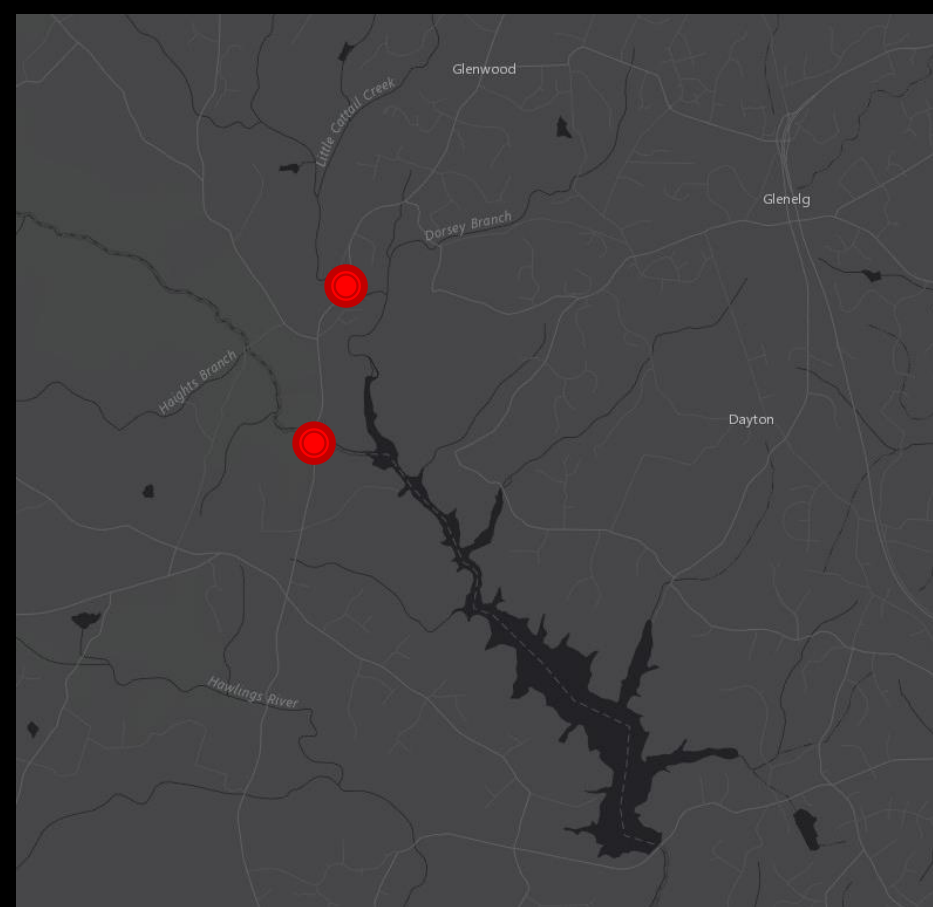
Upstream point at Unity:

Peak 4620 cfs = 10.56 ft

Flood stage = 8 feet

(flooded fields & parking lot near MD 97)

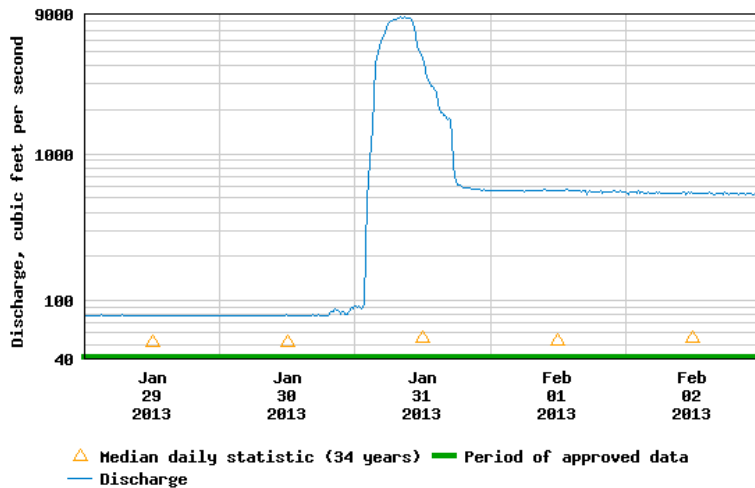
Cattail Creek alone added another 2200 cfs of flow
Dorsey Branch ungauged



2013 Patuxent Flood



USGS 01591610 PATUXENT RIVER BELOW BRIGHTON DAM NEAR BRIGHTON, MD



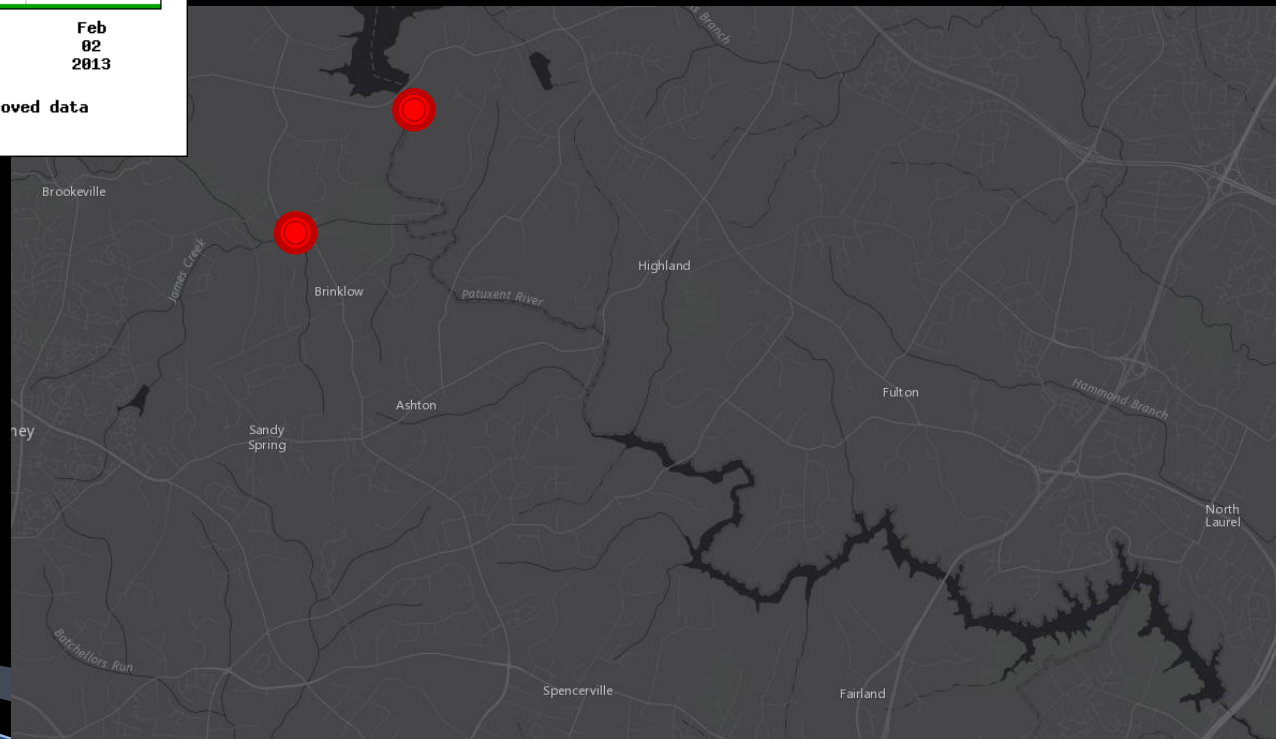
Below Brighton Dam:

Peak 8600 cfs = 11.88 ft

Flood stage = 9 feet

(roads flooded below the dam)

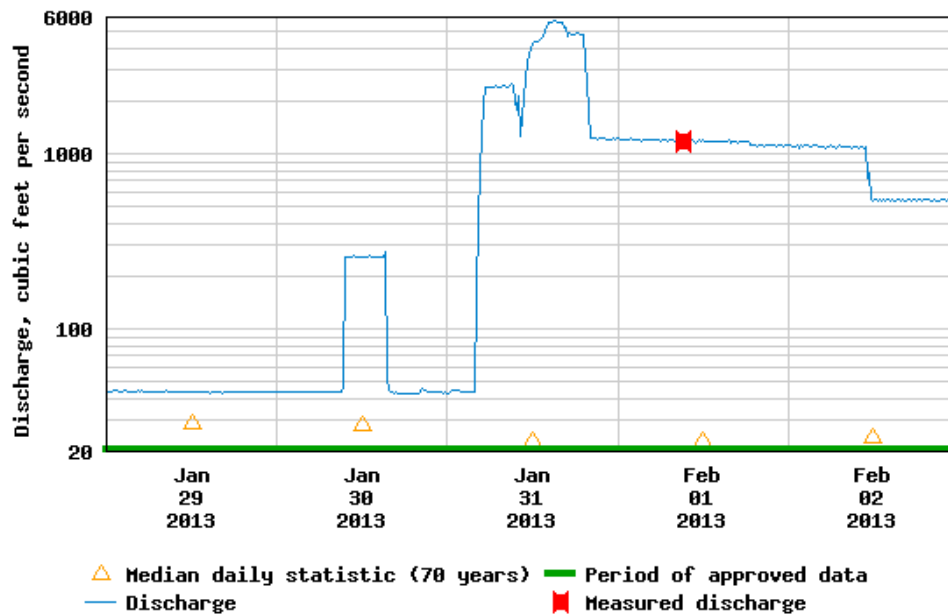
Hawlings River added another 2000 cfs of flow



2013 Patuxent Flood



USGS 01592500 PATUXENT RIV NEAR LAUREL, MD



Below Duckett Dam:

Peak 5770 cfs = 12.79 ft
Flood stage = 9.5 feet
(Laurel Race Track Road floods)

At peak, Duckett Dam only released around half what Brighton Dam & Hawlings River were bringing into the lake, and never passed through as much water as was coming into Brighton from the unregulated streams.

This event could have been much worse!

Had the flow been unregulated, the water level would have been 2-4 feet higher, based on streamflow.



Review

- Stay informed via the NWS website.

weather.gov/washington

or

weather.gov/baltimore

Or use...

mobile.weather.gov

for cell phone display

National Weather Service Forecast Office
Baltimore/Washington

Home News Organization

Local forecast by "City, St" or Zip Code
City, St Go

Find us on Facebook

Current Hazards
MD/DC VA WV
Hazardous Outlook
EM Briefing Page

Current Conditions
Observations
Satellite Images
Hydrology
Rivers&Lakes AnPS
Public Info Stmtnt
Local Storm Reports

Radar Imagery
Sterling Radar
Nationwide

Forecasts
Activity Planner
Text
Español
Aviation
Marine
Discussion
Fire Weather
Tropical
Winter Weather
Graphical
Long Range
Air Quality

Climate
Local
National
More...

Weather Safety
Weather Radio
Storm Ready
SKYWARN®
Safety/Preparedness

Additional Info
Coop Observer
Local Modeling
Past Events
Storm Reports

Top News of the Day [Archived News]
Weathering the Winter Season **NEW!**
2012 Student Volunteer applications due Jan. 27!
Upcoming SKYWARN® classes (updated 1/23)
Forecasts available in Podcast and mp3 formats

Current Temps (°F)
BWI 55 DCA 48 IAD 48

Quick Glimpse at the Weather Baltimore MD/Washington DC
Click on the map below for the latest forecast.

Read watches, warnings & advisories
There are no watches, warnings, or advisories at this time.

Choose from the options below for other ways to view your NWS forecast

Text Forecasts Digital Forecast Quick Forecast Graphical Forecast Images

Radar and Satellite Images



Watch & Warning Review

- ▶ **Hazardous Weather Outlook**
 - Detail on flooding potential through day seven.
- ▶ **Flood Watch**
 - Conditions are favorable for flooding. Check the product for threat details (river/flash/areal)
- ▶ **Flood Warning**
 - Flooding is imminent or nearly certain to occur. Take action immediately!!!



Review

- ▶ Remember...FLOODING KILLS!
- ▶ When a warning has been issued for your area, or you observe signs of imminent flooding, YOU must make the decision to leave flood prone areas and seek higher ground.
- ▶ If you are driving and come to a flooded roadway, STOP! TURN AROUND AND GO ANOTHER WAY.



Review – What to Report

- ▶ **Heavy Rain** – measured 1” or more (we like getting periodic reports & a storm total at end)
- ▶ **Flooding & Flash Flooding** – Streams, creeks or rivers out of banks or flooding of roads from poor drainage



Terminology:

- * Water over banks but not affecting anything – “bankfull/just over bankfull”
- * Water affecting farmland, roads, property out of floodplain – “flooding”



Review – What to report

- ▶ **Ice Accumulation** – Any glaze on surfaces (or more)
- ▶ **Snow Accumulation** – Every 2" and a storm total, or any accumulation not reflected in the forecast



← If half the ground has 2.0" and half the ground is bare, report 1.0" as your total depth.

→ If more than half the ground is bare report "T" (trace) and mention the range of depths in your comments.



Review – How to report

- ▶ Call NWS Sterling as soon as you see something:
(800) 253-7091 or (703) 996-2200
- ▶ You can email delayed reports or pictures to:
LWX-Report@noaa.gov
- ▶ Contact local Emergency Management
- ▶ Amateur Radio (when activated)
- ▶ If you see storm damage after the event, let us know!
Immediate reports are best; but no report is too late!



Questions?

- ▶ **Jason Elliott**
Senior Service Hydrologist
NWS Sterling, VA
- ▶ jason.elliott@noaa.gov

